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THE

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[FOURTH SERIES.]

ART. I.—*On the Pressure Coefficient of Mercury Resistance;* by A. DEFOREST PALMER, JR.

DURING the last fifty years many physicists have investigated the specific resistance of mercury and its variations under different conditions, yet the only determinations of the pressure coefficient, previously published, are those of Barus,* who found $-\cdot00003$ by subjecting commercial mercury to pressures up to 400 atmospheres, and Lenz,† who found $-\cdot0002$ for pure mercury between one and sixty atmospheres. The discordance of these results is far too great to be explained by impurities in the mercury and invites further study.

The long range of pressure desired for the present investigation was easily obtained with Professor Barus's "Screw compressor." This instrument, together with the vertical piezometer employed in my work, has been so fully described elsewhere‡ that only a cursory mention is necessary here. The piezometer proper consists of a cold drawn seamless steel tube, about 6^{mm} internal and 13^{mm} external diameter and 60^{cm} long, connected to the compressor in such a manner that very perfect electrical insulation exists between the two without rendering the joint appreciably leaky. The whole apparatus was filled with heavy mineral oil which, though more viscous than water, attained uniformity of pressure with sufficient rapidity and possessed the advantage of being a very good insulator.

* Barus, this Journal, III, xl, p. 219, 1890.

† Lenz, Stuttgart, 1882; Wied. Beibl., vi, p. 802, 1882.

‡ Barus, Phil. Mag., Oct., 1890, p. 340; Proc. Amer. Acad., xxv, p. 93, 1890; Bull. U. S. Geological Survey, No. 96.

Moreover it is much easier to prevent leakage of oil than water and it has no detrimental effect on the steel parts with which it comes in contact. An Amagat "manomètre à pistons libres"* was used to determine the pressures attained and gave results within one-tenth per cent throughout the entire range. The ratio of its pistons is such that one millimeter difference in height of the mercury column supported by the larger corresponds to a difference of pressure of ·647 atmospheres on the smaller. It is supplied with an open glass manometer three and one-half meters high and is therefore capable of indicating pressures somewhat greater than two thousand atmospheres, but above this limit a large element of uncertainty is introduced by leakage of oil around the pistons.

Commercial mercury was digested for about forty-eight hours in a solution of sulphuric acid and bichromate of potash in water and after being carefully washed, dried, and filtered, was distilled directly into the tubes in which its resistance was measured. An ordinary glass thermometer tube, about 18^{cm} long and $0{\cdot}1^{mm}$ bore, had 10^{cm} of 2^{mm} bore tubing welded to its upper end in such a manner that a cavity, about 1^{cm} long and 4^{mm} in diameter, was formed between the two parts. This cavity and the elongated bulb at the lower end of the fine capillary had platinum electrodes melted through their walls and, when filled, formed the terminals of the mercury thread under investigation. The open end of the large tube was welded to a small glass mercury still connected, through a drying chamber, with a Geissler-Toepler air pump and the whole apparatus exhausted until the pressure fell below one millimeter. When the inside walls had become perfectly dry, heat was applied and mercury slowly distilled over and condensed in the experimental tube. As soon as this became full it was emptied and the operation repeated until the mercury thread, when examined with a magnifying glass, appeared perfectly bright and uniform throughout its entire length. Air was then admitted and the large capillary cut off about two centimeters from the point where it joined the still. After soldering silk insulated copper wires to the electrodes the tube was placed inside the steel piezometer and the upper wire connected directly to it, while the lower one, after passing down through a narrow glass tube, to insure good insulation, was soldered to the inside of the compressor. Oil was forced up into the piezometer and when its appearance at the top showed that all air had been expelled .the opening was closed by a tinned steel screw.

The piezometer was surrounded by a long brass cylinder,

* Amagat, C. R., ciii, p. 429. 1886. Professor Tait has described a similar apparatus in the "Challenger Reports," 1873–76, Physics and Chemistry, vol. ii.

closed at the ends by rubber stoppers, through which water from the city mains was allowed to flow continuously. A thermometer with its bulb inside of this cooler showed that the temperature never varied more than one degree from 9° C. throughout the entire series of experiments and that the variations during the same day were very much less than this. For the measurements at the boiling point of water a tin can about 30^{cm} long and 13^{cm} in diameter, having short brass tubes soldered to apertures in the center of its ends, was placed on the piezometer and fastened, by short pieces of rubber tubing, in such a position that it entirely covered the experimental tube within. Two openings in the top were provided, one for the reception of a thermometer and the other for a vertical water condenser. The latter, being open at the top, kept the steam at atmospheric pressure and at the same time obviated the necessity of frequently renewing the supply of water. The whole arrangement with the exception of the bottom was covered with asbestos to prevent radiation and heat was applied by means of a ring burner surrounding the piezometer below the can. Small water coolers were placed above and below to prevent the conduction of heat through the steel tube to the joints where it might cause leaks.

Various methods for the measurement of resistance were tried with more or less success, but that due to Carey Foster was found to give the best results owing to its sensitiveness to small variations. The general arrangement of the apparatus for this method is too well known to need description here. The transposition of the standard and unknown resistances was accomplished by means of an eight pole mercury commutator similar to those put on the market by Nalder Bros. A series of platinoid coils, by Queen & Co., so arranged that their combined resistance could be varied by tenths from zero to ten thousand ohms, without altering the number of plugs in the circuit, was used as a standard with which to compare the mercury thread under investigation. As noted above, the electrodes of the thread were connected respectively to the piezometer and compressor, and since these parts were otherwise very perfectly insulated from one another they served admirably as poles from which to make connection with the commutator. A very uniform german silver wire, about No. 17 B. & S. gauge, was wound in ten uniform spirals about a vulcanite cylinder 10^{cm} in diameter and $3{\cdot}6^{cm}$ long. Its ends were fastened, in the same generating line of the cylinder, to two thick brass plates that formed the ends of the drum and were rigidly fastened to two stout brass pillars which were connected with the poles of the commutator. An insulated frame work was arranged to revolve about this drum in such a man-

ner that a spring contact, which served as one terminal of the galvanometer, could be readily placed on any point of the wire and its position accurately determined by a large micrometer head divided into one hundred equal parts. This arrangement presents a great advantage over the ordinary form of drum bridge since the only friction connections are in the galvanometer circuit, where the worst effect they can produce is small variations in sensitiveness, and not, as they are usually placed, at the terminals of the wire, where changes in their resistance produce the maximum effect on the result. Current was supplied to the bridge by a single Daniell's cell and was so regulated by a small rheostat in series with the battery that its intensity was never sufficient to appreciably alter the temperature of the resistances in circuit. The attainment of balance was judged by a very sensitive and dead beat D'Arsonval galvanometer of the horizontal magnet type and its indications were observed by the telescope and scale method.

When the Queen resistance box was bought, some years ago, it was accompanied by a certificate from Professor Anthony to the effect that its readings were correct to one-fiftieth of one per cent at 17·5° C. and that its temperature coefficient was ·00023. The coils used in the present investigation have nevertheless been very carefully calibrated and the values thus found used in all the calculations, for, though many of them came quite up to the guarantee, several showed deviations somewhat larger than the probable errors of observation. The resistance of the bridge wire was determined in the following manner. Let the reading of the bridge micrometer, when balance has been obtained, with two nearly equal resistances R and R′ in circuit be x, and when R and R′ are interchanged x'. Then if z and z' are the corresponding readings when R has been increased by a known increment dR it is easy to prove that

$$r = \frac{d\mathrm{R}}{(x-z)+(z'-x')}$$

where r is the resistance of a length of the wire corresponding to one division of the micrometer. About one hundred determinations of this quantity, involving various lengths and different portions of the wire, gave the mean value

$$r = \cdot 000898 \text{ ohms}$$

the greatest difference between a single observation and the mean being less than 3×10^{-6} ohms. These measurements also showed that the error of a single setting of the micrometer was about one-tenth of one division and hence that the mean error of a single determination of a resistance, due to this cause alone, was less than ·0001 ohms. Throughout the entire

investigation the resistances in the various arms of the bridge were so proportioned as to give a maximum of sensitiveness, and a movement of the spring contact on the wire equal to one-tenth of a division was always sufficient to reverse the direction of the galvanometer deflection when balance was obtained. During the measurements at 9° C. no difficulty was experienced from thermoelectro-motive forces, since the water cooler was long enough to keep all the joints at the same temperature, but when the steam jacket was employed they caused so much trouble that it became necessary to replace the copper connections inside of the piezometer by iron wires. Disturbances of this nature were thus reduced to a minimum and trustworthy results could be obtained by closing first the galvanometer and then the battery circuit. The temperature of the room and of the standard resistances, determined by a small mercurial thermometer placed between the coils, remained nearly constant during the actual time of observation but varied considerably from day to day.

If R represents the resistance of the mercury thread and W that of the standard of comparison and if x and x' are the readings of the bridge-wire micrometer for the position of balance before and after they are interchanged, we have

$$R = W + r(x - x')$$

where r has the meaning and value assigned to it above and all the connection resistances are eliminated except those between R and W and the commutator. To determine these the mercury tube was replaced by a thick copper wire soldered to the same connecting wires and measurements were then made under as nearly as possible the same conditions of pressure and temperature that were used with the mercury. The mean of a large number of observations gave ·0632 ohms with the copper connections used at low temperature and ·5095 ohms with the iron ones used at the boiling point, and no variation with the pressure could be detected. In reducing the resistances to the standard temperature of the Queen box the bridge wire was assumed to have the same temperature coefficient and to be always at the same temperature as the standard coils. This assumption could introduce no appreciable error in the results, since the factor $r(x-x')$ was always less than 0·1 ohm and the temperature of the room never varied much from that of the box, but it greatly simplified the calculation of the corrections. It was further found that the slight variations in the temperature of the mercury thread, from 9° C. in one case and from 100° C. in the other, introduced errors that could not be neglected and corrections were introduced using ·0009 as the temperature coefficient of mercury. Finally the effect of changes in the volume of the glass tube, due to compression,

were eliminated on the assumption that the coefficient of cubical compressibility of the glass used was ·0000025. Calculations were instituted to determine the effect on the measurements of the slight changes in pressure, and hence in the resistances of the mercury thread, due to leakage of the compressor and gauge between the direct and reverse settings of the bridge wire contact, and it was found that the errors so introduced were generally so small and their calculation so uncertain that no appreciable benefit could be obtained by attempting their correction.

TABLE I.

P	R	R′	R−R′	P	R	R′	R−R′
1	12·470	12·451	·019	1199	11·963	11·956	·007
57	12·414	12·428	—·014	1400	11·871	11·872	—·001
149	12·382	12·390	—·008	1651	11·749	11·768	—·019
241	12·344	12·352	—·008	1890	11·678	11·669	·009
301	12·308	12·327	—·019	1984	11·637	11·630	·007
386	12·294	12·292	·002	113	12·406	12·405	·001
459	12·265	12·262	·003	186	12·374	12·375	—·001
515	12·250	12·239	·011	282	12·333	12·335	—·002
544	12·228	12·227	·001	378	12·302	12·295	·007
581	12·205	12·211	—·006	461	12·255	12·261	—·006
1	12·456	12·451	·005	537	12·236	12·230	·006
1	12·452	12·451	·001	623	12·195	12·194	·001
375	12·261	12·297	—·036	692	12·168	12·165	·003
552	12·215	12·225	—·010	777	12·142	12·130	·012
581	12·216	12·211	·005	867	12·071	12·100	—·029
605	12·200	12·201	—·001	133	12·396	12·396	·000
649	12·192	12·183	·009	881	12·105	12·087	·018
729	12·163	12·150	·013	918	12·094	12·072	·022
1441	11·837	11·855	—·018	990	12·050	12·042	·008
1504	11·809	11·829	—·020	1045	12·035	12·019	·016
1574	11·785	11·800	—·015	1173	11·976	11·966	·010
1619	11·765	11·782	—·017	1230	11·942	11·943	—·001
1686	11·740	11·754	—·014	1297	11·919	11·915	·004
1755	11·719	11·725	—·006	1369	11·878	11·885	—·007
1831	11·702	11·694	·008	1425	11·858	11·862	—·004
1923	11·666	11·656	·010	1479	11·838	11·839	—·001
177	12·378	12·378	·000	1542	11·815	11·812	·003
359	12·306	12·303	·003	1571	11·828	11·801	·027
532	12·230	12·231	—·001	154	12·388	12·388	·000
684	12·180	12·169	·011	154	12·388	12·388	·000
851	12·116	12·100	·016	106	12·406	12·408	—·002
1047	12·020	12·018	·002	106	12·403	12·408	—·005

Five or ten minutes were always allowed to elapse after each increment to the pressure before the resistance measurements

were made in order that the irregularities in temperature, due to compression, might become equalized and the distribution of pressure throughout the whole apparatus become uniform. It was also possible by this method to determine whether the rate of leakage was sufficient to seriously affect the results and when this was found to be the case to adopt means to prevent it. The observations at 9° C. are given, in the order in which they were taken, in table I, and those at 100° C. in table II, where the columns P and R contain respectively the pressure in atmospheres and the corresponding corrected resistances in ohms. The chart, fig. 1, shows the same data graphically, the horizontal scale being one hundred atmospheres and the vertical one-tenth ohm per division. The base line corresponds to 11·6 ohms and the temperature at which each series was made is marked above it.

TABLE II.

P	R	R′	R−R′	P	R	R′	R−R′
88	13·388	13·360	·028	1521	12·711	12·714	−·003
161	13·348	13·327	·021	1600	12·685	12·678	·007
239	13·310	13·292	·018	1690	12·644	12·638	·006
325	13·257	13·253	·004	1788	12·603	12·594	·009
407	13·227	13·216	·011	1895	12·573	12·545	·028
471	13·204	13·188	·016	1969	12·518	12·512	·006
531	13·177	13·160	·017	2139	12·459	12·435	·024
572	13·156	13·142	·014	2214	12·430	12·401	·029
647	13·125	13·108	·017	59	13·378	13·373	·005
697	13·103	13·086	·017	210	13·299	13·305	−·006
739	13·069	13·067	·002	316	13·246	13·257	−·011
801	13·030	13·039	−·009	420	13·207	13·211	−·004
862	13·014	13·011	·003	513	13·148	13·168	−·020
904	12·982	12·992	−·010	596	13·114	13·131	−·017
947	12·974	12·973	·001	713	13·047	13·078	−·031
1008	12·931	12·945	−·014	834	13·004	13·024	−·020
1053	12·920	12·925	−·005	955	12·939	12·969	−·030
1156	12·865	12·878	−·013	1067	12·898	12·919	−·021
1235	12·830	12·843	−·013	1199	12·845	12·859	−·014
1293	12·824	12·817	·007	1324	12·800	12·803	−·003
1306	12·797	12·811	−·014	1441	12·721	12·750	−·029
1400	12·762	12·768	−·006	1599	12·684	12·679	·005
1468	12·743	12·738	·005	1741	12·616	12·615	·001
1509	12·724	12·719	·005	1877	12·574	12·553	·021
1580	12·693	12·687	·006	2029	12·476	12·485	−·009
1652	12·668	12·655	·013	2113	12·481	12·447	·034
1705	12·647	12·631	·016	2236	12·339	12·392	−·053
1719	12·625	12·625	·000	1838	12·567	12·571	−·004
9	13·394	13·396	−·002	1409	12·746	12·764	−·018
1292	12·834	12·817	·017	1023	12·908	12·938	−·030
1368	12·763	12·783	−·020	587	13·107	13·135	−·028
1452	12·733	12·745	−·012	103	13·401	13·354	·047

Combining these observations by the method of "Least Squares" we have

at 9° C. $R = 12{\cdot}4518 - {\cdot}000414P$
at 100° C. $R = 13{\cdot}3999 - {\cdot}000451P$

The lines on the chart have been drawn in accordance with these equations, and it will be seen that the plotted points are very nearly in coincidence with them. The values of R computed by these formulæ have been entered in the tables under R′ and the relative errors, from which the probable error of a single observation has been found to be ·008 ohms at 9° C. and ·012 ohms at 100° C., under R−R′. Hence the resistance measurements are accurate to less than one-tenth of one per cent and are as good as could be expected when it is remembered that the uncertainty in determining the pressure is about the same in magnitude and that it is impossible to entirely prevent leakage when very high pressures are employed. Furthermore small errors were probably introduced by the lag in the indications of the mercurial thermometers behind the actual temperature variations. Putting the above equations in the form

$$R = R_0(1+\beta P)$$

where β is the increment to unit resistance caused by one atmosphere increase in pressure, we have, after calculating the probable error in the usual way from the sum of the squares of the errors,

at 9° C. $\beta = -{\cdot}00003324 \pm {\cdot}00000014$
at 100° C. $\beta = -{\cdot}00003367 \pm {\cdot}00000019$

Hence it follows at once that at any temperature

$$\beta = -{\cdot}0000332 - 5 \times 10^{-9}\, t$$

where the last term, owing to its extreme smallness, is probably only approximately accurate.

The difference between this result and that of Barus (−·00003) is so small that it can be easily accounted for by the slight impurities in the commercial mercury used by him. Lenz's original paper is unfortunately inaccessible and the account of it in the Beiblätter is meager. He used a tube 1·2 meters long filled at atmospheric pressure, and it is probable that the very large coefficient (−·0002) obtained was due to the imperfect removal of air bubbles from its inside walls, a source of error having its maximum effect at the low pressures employed by him.

The two series of observations marked by circles on the chart, fig. 1, are so obviously affected by consistent errors that they have been left out of the calculations. The first was

obtained after the apparatus had been left sustaining a pressure of about 750 atmospheres for two hours and lies below the line, while the second, obtained after rapidly increasing the pressure from one to 1640 atmospheres, lies above it. Similar

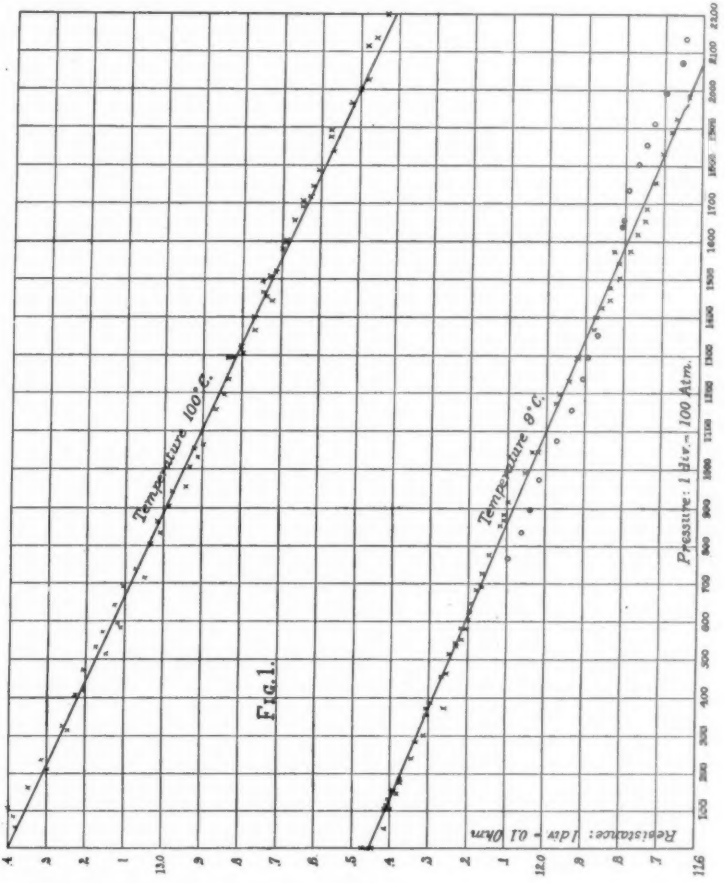

FIG. 1.

operations at another time failed to produce similar results and an entirely satisfactory explanation does not present itself, but it is probable that the first is due largely to imperfect freedom of the gauge pistons, caused by particles of dirt in the oil leaking past them, and the second to the heat produced by rapid compression.

Brown University, March 18, 1897.

ART. II.—*On Ctenacanthus Spines from the Keokuk Limestone of Iowa;* by C. R. EASTMAN.

THROUGH the courtesy of Mr. Lisban A. Cox, of Keokuk, Iowa, the writer has recently been able to study certain Selachian remains obtained from the so-called "lower fish-bed" in the vicinity of Keokuk, and now preserved in the private collection of Mr. Cox. Two very perfect fin-spines were considered by this gentleman to be new, as they differed from anything he had ever observed from this horizon or elsewhere during his long experience as a collector. It will be seen from the following that he was largely justified in his conclusions.

The larger of the two ichthyodorulites belongs undoubtedly to the genus *Ctenacanthus*. It preserves a length of 20·5^{cm}, and is 2·6^{cm} in maximum width; possibly 1·5 or 2^{cm} are wanting from the distal extremity, but the base is entire. It is gently arcuate in form, the anterior margin being more strongly and regularly convex than the posterior; and it is laterally much compressed. Its general shape and proportions agree with those of a unique spine from the same horizon, upon which St. John and Worthen* founded the species *Acondylacanthus? xiphias*, the chief difference consisting in the ornamentation. But these authors are careful to state that their specimen was much abraded, and it was referred to *Acondylacanthus* with considerable hesitancy on that account. Although admitting that if found to possess nodose costæ it would have to be transferred elsewhere, they concluded that "in the absence of any such ornamentation and the apparent smooth plain costæ, its affinities are clearly with the above genus [*Acondylacanthus*]." They also point out that "the typical forms of *Acondylacanthus* are more slender and proportionately narrower, than the above described form."

There seems to be every reason for believing that the type of *A. ? xiphias* and the specimen now under consideration represent two examples of the same species, the differences between them being only such as are due to different conditions of preservation. In this event the name must be changed to *Ctenacanthus xiphias*, and the specific definition will require emendation, so as to include characters not observed on the original specimen.

As may be seen from the accompanying figure, there is no species with which these Keokuk spines are so closely related as *C. denticulatus* M'Coy, from the Lower Carboniferous of England and Ireland. There is a remarkable resemblance to

* Palæontology of Illinois, vol. VII, p. 244, pl. xxvi, fig. 1.

this form, both in size, shape, and details of ornamentation. The longitudinal costæ are of round cross-section, about the same distance apart, and are denticulated or collared in the same manner in both forms. In *C. xiphias*, however, they arise less frequently by dichotomy, and as far as can be learned from the present specimen, the series of denticles on the posterior face is nearly obsolete. Only the bases of these denticles are preserved on the specimen, but they are quite faint, and appear to be limited to the distal half of the spine. The exserted portion is very obliquely demarcated from the base, and the pulp-cavity remains open for quite a distance beyond it. No evidence of a keel appears on either face, but along the anterior margin two longitudinal costæ, arising one on either side, unite to form a blunt ridge serving as a cutwater. The inserted portion tapers more gradually than in *C. denticulatus* and most other species. A knowledge of these characters enables us to frame a more complete diagnosis of this species, as follows:

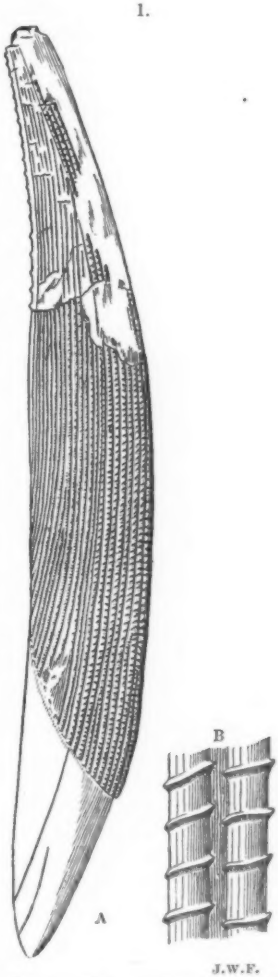

FIG. 1.—*Ctenacanthus xiphias* (St. John and Worthen). *A*, Spine ⅔ natural size. *B*, Ornamentation 4 times enlarged.

Ctenacanthus xiphias (St. John and Worthen).

Spines attaining a length of over 20^{cm}, moderately curved, the anterior margin more strongly convex than the posterior; gradually tapering, and laterally very much compressed. Base deeply embedded, tapering, and obliquely marked off from the exserted portion; pulp cavity continued in a posterior channel for about half the total length of the spine. Denticles of posterior angles uniformly spaced, more or less rudimentary. Ornamentation consisting of parallel longitudinal ridges, rarely bifurcating or implanted, rounded, about their own diameter

apart, and decreasing in size toward the posterior face. Each of the costæ is denticulated by numerous sharp folds, which extend half way across the intercostal spaces, and are separated from each other by about the thickness of the ridge. The anterior edge of the spine is formed by a ridge wider than the rest, and of compound origin.

The second ichthyodorulite that deserves notice represents a new species of *Ctenacanthus*. It will be seen from the annexed illustration that the spine is very nearly perfect, only the extreme tip being broken away. It is 12·5^{cm} long, and not quite 1·5^{cm} in maximum width. Its stylet-shaped form, nearly rectilinear edges, and the nature of its ornamentation readily distinguish it from all other species. In cross-section it is less compressed than most spines belonging to *Ctenacanthus*. The posterior face is embedded in the matrix, but the latter has been removed along one edge sufficiently to reveal a series of small denticles standing at right angles to the axis of the spine. A convenient fracture makes it possible to remove the base, thus displaying the pulp-cavity at that point. It is of ample size, and is continued for a short distance upward in an open groove as in other species. Another fracture higher up presents the cross section shown in fig. 2*B*, from which it will be seen that a posterior keel is present.

FIG. 2.—*Ctenacanthus acutus* sp. nov. *A*, Spine ½ natural size. *B*, Cross-section of same.

Owing to abrasion, the longitudinal costæ appear nearly smooth except along the posterior edges, where they retain their tuberculation. The tubercles are quite small, and resemble those of *C. keokuk;* a few are also distributed in the intercostal grooves, thus indicating an approach to *Asteroptychius*. Besides bearing tubercles, the costæ appear to have been denticulated along their sides, as indicated by transverse markings in many of the intercostal spaces. The ridges are triangular in cross-section, increase in number downward by dichotomy, and are much crowded towards the posterior face; some of them appear longitudinally striated when worn. The anterior margin of the spine is formed by the concrescence of several ridges, and becomes thickened in consequence.

The definition of this species may be summarized briefly as follows:

Ctenacanthus acutus **sp. nov.**

Medium sized spines with margins of the exserted portion almost perfectly straight, tapering gradually toward the apex; base deeply embedded; posterior angles closely set with a row of small denticles arising perpendicularly. Longitudinal costæ numerous, triangular in section, bearing minute tubercles on their summits, and denticulated along the sides; increasing by bifurcation. Posterior face with a median longitudinal keel.

Including the two species described above, the Keokuk limestone is known to yield six representatives of *Ctenacanthus*, and in all ten "genera" of ichthyodorulites. Some of the latter, however, are unsatisfactorily determined. Following is a list of the *Ctenacanthus* species:

C. acutus Eastman.
C. coxianus St. J. and W.
C. cylindricus Newberry.
C. excavatus St. J. and W.
C. keokuk St. J. and W.
C. xiphias (St. J. and W.)

Museum of Comparative Zoology,
Cambridge, Mass.

ART. III.—*Studies in the Cyperaceæ;* by THEO. HOLM. V. *Fuirena squarrosa* Michx. and *F. scirpoidea* Vahl. With 19 Figures (pp. 25, 26).

THESE two species are natives of the eastern United States, *F. squarrosa* showing a distribution from Massachusetts as far south as subtropical Florida, while the other species is confined to Georgia and Florida alone. It is a marked characteristic of the genus that a true perianth is developed, in our species represented by six leaves in two alternating whorls, those of the inner being spathulate, while the others are merely bristle-shaped like those of *Dulichium*, *Rhynchospora*, etc.; this, the outer, whorl of the perianth is, however, undeveloped in several of the foreign species of *Fuirena*, as well as in *F. umbellata*, upon which Rottböll established the genus, first discovered in Surinam by Rolander, who described it as "*Scirpus tripetalos.*" The genus is closely related to *Scirpus*, with which it, also, shows a great resemblance in regard to the general habit, but is well distinguished by the spathulate shape of the perianth as also by the hairy bracts of the flowers, which are smooth in the species of *Scirpus*. When compared with each other, our two *Fuirena*-species show several external characters, by which they are readily distinguished, viz: the reduction of the stem-leaves in *F. scirpoidea* to sheaths with a minute blade, while *F. squarrosa* has well-developed leaf-blades. The bracts of

the flowers are broad and very short-pointed in *F. scirpoidea* (fig. 13), but rather narrow and long-awned in the other species (fig. 11). The inflorescence is a spike, there being one terminal and several lateral, often situated close together or scattered on long peduncles from the axils of the stem-leaves as in *F. squarrosa*. A clado-prophyllon is present and is short, very broad and distinctly bidentate in *F. scirpoidea* (fig. 12), while it varies from oblong, slightly emarginate to long and tubular in *F. squarrosa* (figs. 6 and 10), in accordance with its place on the very short rhachis of the lateral spike or at the base of the long peduncles, which bear several spikes at the apex, and which are commonly developed in the axils of some of the lower stem-leaves in *F. squarrosa*.

Another character is to be observed in the shape of the inner perianth-leaves, which, although they are spathulate in both species, are almost obtuse in *F. scirpoidea*, but vary from short-pointed to long-awned in the other species; a similar variation in regard to the respective length may, also, be noticed in the bristles. The rhizome of our species shows a very considerable difference, being stout and extensively creeping in *F. scirpoidea* in contrast to that of *F. squarrosa*, which is almost cæspitose with ascending, not creeping, shoots and which, also, possesses some tuberous organs, each of which represents a single internode.

We see from these divergencies that our two *Fuirena*-species do not lack morphological characters; all of which are of specific value, and we shall show, later on, in this article that their internal structure is no less important for their specific distinction. We must, however, not neglect to consider our plants also from a biological point of view; and we shall try to demonstrate, at least, a part of their life-history, based upon our investigations and compared with the more important studies of similar kind, which we have met with in our literary research. There are, for instance, in regard to the germination of *Fuirena* a few points of interest, which deserve notice, although they are not new; nevertheless, when we discuss them, it is merely on account of the very defective knowledge we have of the seedlings of this group of plants, the *Cyperaceæ*, and we thought, also, that a brief historical sketch of this early stage of their life-history might be of some interest to the reader.

The principal difference, that exists between the germination of the *Cyperaceæ* and the *Gramineæ*, consists in the fact that in the *Cyperaceæ* the plumule is the first to push out through the caryopsis, while in the *Gramineæ* the primary root is the first to appear. In *Fuirena* as in the other *Cyperaceæ*, which so far have been examined, the plumule is covered

by a membranous sheath at the base of which a small, roundish wart soon becomes visible, and which represents the primary root. The cotyledon, on the contrary, stays inside the seed, its function being to absorb the endosperm. These are the general features of the germination, and it may, at first glance, seem to be a very easy matter to define these various organs, which as we have shown constitute the seedling. We may, by considering our figure 1*b*, define the conical body (C) as representing the cotyledon and as being identical with the scutellum of the *Gramineæ;* we may define the sheathing leaf (*Sh*) as the second leaf, and L′ as the first developed green leaf. The primary root (R) is already relatively long and covered with root-hairs. By comparing now this figure (1*b*) with our figure 1, we notice the same organs, besides a stem-part (*j*) which separates the cotyledon (C) from the sheathing leaf (*Sh*); a secondary root (*r*) has developed from this stem-part, and another one (*r′*), but much younger, has started to break out through the base of the sheathing leaf (*Sh*). One should, according to these figures, never doubt the morphological identity of these organs, as we have defined them above, especially when we point out the long internode (*j*) which lies between the cotyledon (C) and the sheathing leaf (*Sh*), viz: that these organs should not be independent of each other. It seems, nevertheless, to be a most difficult task to define them correctly, so as to bring them in strict conformity with the corresponding organs in the other monocotyledonous plants, and at the same time avoid bringing their anatomical structure in contest with their rank in a morphological respect. If we, for instance, consider the body at C as the cotyledon, its structure must correspond with that of a leaf, and if we, also, define the sheathing organ at *Sh* as a leaf, this must not be in any connection with the other one at C; furthermore, if the stem-part (*j*) is really an internode, it must show a structure in conformity herewith. The difficulty is, however, that these organs do not exactly show the anatomical structure as they "ought," according to our idea, and even if a morphological consideration may seem more natural, we cannot feel justified in overlooking the structural characters. We will, therefore, in our attempt to explain this matter, strive to establish a conformity, so that the morphological peculiarities may be brought in accordance with the anatomical ones, and we believe this may be attained by presuming that some modification exists in the development of some of these organs. A literary research upon this question is exceedingly instructive, and there are, indeed, few stages in the plant life that have required so many and such able investigations in order to become understood, as has the germination of the *Gramineæ* and the *Cyperaceæ*.

The *Gramineæ* seem, however, to have attracted a good deal more attention than the *Cyperaceæ*, although their seedlings agree in most respects. It is, now, interesting to see from the literature how many and very diverse opinions have been expressed by the morphologists in order to define the organs of these seedlings; and even if so eminent an anatomist as Van Tieghem has tried to pacify the contesting parties by submitting a most excellent and detailed account of the internal structure of these germinating plantlets, it seems, nevertheless, that the morphological standpoint taken by Warming, in adherence to the views expressed by Poiteau, Mirbel and Turpin, may prove satisfactory to all concerned.

The most important difference between the seedlings of these two families consists in the presence of a very small organ like a rudimentary leaf, which in some *Gramineæ*, but not in all, is to be observed on the anterior face of the seedling, and in alternation with the so-called scutellum. This scale-like appendage had been observed and figured by Malpighi as far back as the year 1675, and it has since that time been repeatedly described and given a number of names, the best known among these being the "lobule" of Mirbel, and the "épiblaste" of Richard. While Poiteau, Mirbel and Turpin considered this organ as an independent leaf or even as a "second, but small cotyledon," the majority of the other authors have only understood it as a part of the cotyledon. It is strange, that the most modern and generally adopted idea is now that of Gärtner (l. c.), who more than a hundred years ago defined the scutellum as the median part of the cotyledon, the épiblaste or lobule as an appendix to this, while the sheathing leaf (*Sh*) should represent the ascending sheath of the cotyledon, thus these three organs should all constitute the cotyledon, and the first green leaf (L′) should then be the first leaf of the plant next to the cotyledon. This rudimentary organ, the épiblaste, is not known to exist in the *Cyperaceæ*, and we have therefore great difficulty in finding proofs for our explanation, according to which the cotyledon and the sheathing leaf should represent organs, independent of each other. It will be seen from our drawings (figs. 1 and 1*b*) that the sheathing leaf (*Sh*) is situated just above and at the same side of the axis as the cotyledon (C), indicating a leaf arrangement as "uniseriate" which would be too unnatural to be acceptable. But when we compare our *Fuirena*-seedlings with similar ones of *Gramineæ* "with or without the épiblaste," the suggestion arises that this little organ has been suppressed in the *Cyperaceæ*, as in a number of the *Gramineæ*. Seedlings of grasses with a developed épiblaste show the same biseriate arrangement of the leaves as we find later on in the mature

plants, counting the cotyledon as the first, the épiblaste as the second and the sheathing leaf as the third leaf of the young plant. We might be allowed to suggest that the épiblaste has become undeveloped in the *Cyperaceæ*, but without influencing or rather without disturbing the normal arrangement of the leaves, as we find them in *Fuirena* and all the others examined. It was the frequent development of a stem-part between the cotyledon and the sheathing leaf, which led Warming to adopt the explanation of these three organs, including the épiblaste, as independent; but, strange to say, Warming does not in his paper upon this subject (l. c.) enter into any discussion as to the severe objections raised by Van Tieghem against this theory. Van Tieghem denounces the épiblaste as a leaf, because it does not receive any mestome-bundles from the axis; the sheathing leaf will, therefore, necessarily be situated above and "at the same side" as the scutellum, and can consequently not be independent of this. He, finally, demonstrates that the supposed internode (*j*) is only a node according to its anatomical structure, but a node, which has become unusually stretched, so that the cotyledon and the sheath have become somewhat separated from each other. These very serious objections are, of course, a heavy blow to the theory regarding the existence of three independent leaves, an explanation which otherwise seems so very natural and in good conformity with the rules of morphology. We venture, however, to suggest that the épiblaste may be a leaf-primordium and that it stays as such with no mestome-bundles developed, and as a leaf, which is often suppressed entirely. We will, also, state that we cannot find any decided objection in considering the cotyledon as a leaf, independent of the épiblaste and of the sheathing leaf, even if, as Van Tieghem has proved, the stem-part is only a node. There is among the numerous and most important agrostologic papers by Duval-Jouve one (l. c.) in which he describes the nodes of *Eleusine*, *Cynodon* and other *Gramineæ* as bearing more than "one leaf," from one to two or even three! This same fact is very familiar to us, when we remember the peculiar, dense-leaved nodes of *Diplachne*, *Munroa*, *Buchloë* and several other North-American grasses. We might also state, that it is not quite certain that the épiblaste is constantly present only as a rudimentary organ, since Didrichsen (l. c.) has figured this organ taken from *Avena sativa*, where it shows a distinct nervation, corresponding to a very finely lobed margin. We believe, however, that a continued research will throw a clearer light upon this subject, and there is no doubt that seedlings of our native grasses and sedges will show some facts that may be helpful for the explanation of this remarkable manner of germinating. We will,

also, at this place, call attention to a work by Klebs (l. c.), wherein is given a summary of the different manners of germination, considered from a morphological as well as from a physiological point of view, besides that this author has enumerated the most prominent works upon the subject, which, of course, is a most valuable guide for literary research.

Having discussed now the germination of our plants, let us examine them at a later stage, when their vegetative organs are fully developed; and we may begin with the rhizome. We have already mentioned above, that the rhizome of our two species shows a very marked difference in external structure, although their manner of ramification is exactly the same in both species. We find here a true sympodium, and the difference lies merely in the tuberous development of some internodes in *F. squarrosa*. While the sympodial ramification is very common in the Phanerogames, especially in their rhizomes, there are, nevertheless, only a few which exhibit the sympodium so plain as our *Fuirena scirpoidea*. Figure 7 illustrates the anterior part of a rhizome of this species, and we have, also, redrawn the apex of the same, but on a larger scale in order to represent the exact position of each organ (fig. 8). The rhizome is horizontally creeping and consists of distinct internodes with scale-like leaves. At certain intervals, in our species, between each two leaves, a flower-bearing stem arises, while an axillary bud develops at the same time, continuing the growth of the rhizome in the same direction, as if it was the terminal bud. By comparing figs. 7 and 8, we notice the scale-like leaf B, which is borne on the main axis (ax^1) and which at the same time supports another, but secondary axis (ax^2), which is readily seen to be axillary. These two axes (ax^1 and ax^2) have fused together and form partly a single internode, but there is a somewhat depressed line to be seen where the fusion has taken place, and the axillary branch is, always, well-marked by having its first leaf developed as a bicarinate prophyllon (*pr* in fig. 8) with its characteristic position in regard to the main-axis. The rhizome of *F. scirpoidea* does not branch much to the sides, but when such branches develop, they always originate from the axil of the lowest situated leaf of a flowering stem (fig. 9), while we have not observed any to be developed from the scale-like leaves, excepting from the apex of the rhizome, as described above.

The same sympodial ramification is, also, to be found in the other species, *F. squarrosa*, some parts of the rhizome of which are illustrated in figures 2 and 4, in addition to some diagrammatical drawings in figs. 3 and 5 of the same parts. Figure 3 shows, for instance, the apex of an old rhizome (fig. 2) where B is a scale-like leaf from the main stem, the continuation of

which (ax^1) attains a peculiar tuberous development of the internode above the leaf (b). Another shoot pushes out from the axil of the scale-like leaf B, which is, consequently, of second order (ax^2), and which develops into a leaf-bearing shoot of normal structure. We find this same manner of development if we consider figure 5, which represents an enlarged portion of the rhizome (fig. 4). We see, also, here the two systems of axes (ax^1 and ax^2) one of which (ax^1) shows the same tuberous internode (i^2) as described above. The axillary shoot (ax^2) bears here two scale-like leaves (b^1 and b^2), of which the upper one (b^2) supports the shoot, ax^2, well distinguished as axillary by its prophyllon (pr). This figure shows, then, the development of the axis of first order either as a flower-bearing stem with stretched internodes, or as a tuberous shoot with the growing-point arrested in its further development; the axis of second order seems, also, in this species to stay underground as purely vegetative. In regard to the tuberous development of one of the internodes of *F. squarrosa*, we must state, that this seems to be a very rare case in the *Cyperaceæ*, while tubers of several internodes are known from a few species of *Cyperus*, e. g. *C. esculentus* and *C. phymatodes*, which have been described in a very clear and comprehensive manner by Seignette (l. c.) In the *Gramineæ*, on the contrary, such single tuberous internodes are not very rare, and Hackel (l. c.) enumerates quite a number of grasses, representing a development like that of *Fuirena squarrosa*. These grasses are mostly inhabitants of regions of which a periodical drought is characteristic, and Hackel mentions for instance the Pacific species of *Melica*, some Mexican species of *Panicum*, the genus *Ehrharta* from the Cape Colony, besides several species from the Mediterranean.

In regard to the stem above-ground, this is in *F. scirpoidea* built up of a number of rather short internodes, of which all the leaves are merely present as sheaths, the blade being only a rudiment; the stem of the other species is of usual form, but none of the internodes is, however, long enough to be defined as a scape. The leaves of *F. squarrosa* have long, linear blades, like the tubular sheath very hairy; a ligule is, also, developed as usual in the long-leaved *Cyperaceæ*, and it is very strange that this organ seems almost constantly to have been overlooked in this family, although it is very distinct, when developed. Baillon (l. c.) and Bentham and Hooker have even considered the ligule as one of the generic characters of *Fuirena*, viz: "foliorum vagina ligula coronata." It is, on the other hand, just as incorrect when the authors of botanical manuals constantly attribute this same organ, the ligule, to all the *Gramineæ* without exception, although it is absent in

many, e. g., all the broad-leaved species of *Panicum*, viz: *P. microcarpon*, *viscidum*, *clandestinum*, etc. We have already described the structure of the inflorescence and of the single flowers, and having not observed any other characters of morphological interest, we will proceed to the anatomical part of our paper.

The rhizome.

This shows a very firm structure in *F. scirpoidea*, since the bark-parenchyma contains a concentric ring of small groups of very thick-walled stereome, besides that a closed ring of several layers of this same tissue, the stereome, surrounds the central-cylinder. The mestome-bundles seem to be all collateral, and are supported by stereome on their hadrome-side; they are not arranged in any order, but scattered in the large mass of fundamental tissue. We mentioned in our previous article upon *Dulichium* the presence of tannin-reservoirs, which we have noticed again in both species of *Fuirena*. These reservoirs are quite numerous in the rhizome, especially in the outer layers of the bark-parenchyma.

By examining the rhizome of *F. squarrosa*, the internodes of normal thickness showed a large quantity of starch deposited in the bark and in the fundamental tissue, which occupies the greater part of the central-cylinder. Immediately inside the epidermis some small groups of stereome are to be observed, and this tissue appears again in about three or four strata, forming a closed ring inside the bark, and surrounding the central-cylinder. A thin-walled endodermis is very distinct, and the collateral mestome-bundles are arranged very regularly in three alternating bands, with their hadrome-side supported by thin-walled stereome; similar, but smaller, mestome-bundles were, also, observed in the bark. Tannin-reservoirs were observed to be quite numerous and of large size in the bark.

If we now compare this structure with that of a tuberous internode, we notice the almost complete disappearance of the stereome, and also that there is here only one single band of collateral mestome-bundles, located a very short distance from the epidermis. The fundamental tissue occupies the greatest part of the internode and is filled with starch. It appears from this, that the function of these thickened internodes is for the storage of nutritive matters; in the *Gramineæ*, however, their function is different, according to Hackel's observations, who states that he was unable to find any deposits of starch in their swollen internodes, although these were examined at different seasons of the year. He, therefore, concludes that they may represent a kind of water-

reservoirs, which might be of some use to these plants in the dry seasons. A different view has, meanwhile, been expressed by Seignette, who (l. c. p. 39) describes the structure of *Avena elatior* var. *bulbosa* (*A. bulbosa* Willd.), and who found a large quantity of starch deposited in the fundamental tissue.

The stem above-ground.

It is cylindric, but furrowed in *F. scirpoidea*, and, as already stated, consists of numerous internodes. The epidermis-cells are relatively small, perfectly smooth, and stomata are, of course, well represented in this tissue. The bark-parenchyma shows a very characteristic palissade-tissue of several layers, and is interrupted by large groups of stereome. The inner part of the bark passes gradually over into a colorless tissue, which occupies the interior part of the stem; the mestome-bundles are arranged in a band and are to be observed in the green bark, just inside the groups of stereome, which border on their colorless parenchyma-sheaths. A very few mestome-bundles are, also, noticed in the fundamental tissue, and these show a much larger lacune in the hadrome-part than is to be observed in the bundles of the outer band. The stem of *F. squarrosa* shows a somewhat different structure; it is terete, furrowed and smooth, but much weaker than that of the preceding species. The cells of epidermis are large and very thin-walled, and the green bark consists only of about seven strata, in which lacunes are to be observed. The mestome-bundles are arranged in two alternating bands and located in the very large, colorless-parenchyma, which occupies the central-cylinder; the bundles are supported by large groups of stereome, which reach through the green bark to the epidermis itself. Characteristic of the stem of this species is the presence of lacunes, one between each of the two mestome-bundles and several in the fundamental tissue, rendering the stem almost hollow.

The leaf

of *F. scirpoidea* has a long, tubular sheath but only a minute, rudimentary blade. A transverse section of the blade (fig. 17) is thick, but very narrow. The epidermis consists of rather large cells, but none of them are, however, developed as "bulliform," although some of the cells above the midrib are considerably larger than the others; stomata (fig. 18) are especially abundant on the inferior face of the small leaf-blade as well as on the sheath. These stomata are not prominent, but almost in niveau with the surrounding cells. The mesophyll (the black tissue in fig. 17) consists of rather closely-packed

roundish or polyëdric cells, none of which are differentiated as palissade-cells. There are only a few, about seven, mestome-bundles, of which the median one is the largest; they are all surrounded by thin-walled and colorless parenchyma-sheaths inside of which we meet with a typical mestome-sheath. The hadrome-part is rather large, and contains a number of vessels. There are groups of stereome on the leptome-side of the mestome-bundles, while this tissue is almost wanting on the hadrome-side, excepting in the median bundle. Reservoirs of tannin were noticed as being very abundant in the mesophyll. A more complete structure is shown by the long leaf-blade of *F. squarrosa* (fig. 14). Epidermis consists of very large cells on the superior face of the blade, and is developed as "bulliform-cells" above the midrib and two of the largest mestome-bundles. Hairs are abundant in this species, and are present as very short ones on the superior face of the blade, while those of the margins and the inferior face are long and sharply pointed. The stomata (fig. 15) are very prominent, and seem only to be developed on the inferior face of the blade. The mesophyll is well developed, consisting of hexagonal very closely-packed cells, while a large lacune is to be seen between each of the two mestome-bundles. These last are surrounded by colorless, thin-walled parenchyma sheaths as well as by the usual mestome-sheath, and the larger bundles are on both faces supported by some small groups of stereome.

The root

of *F. scirpoidea* agrees in most respects with that of the other *Cyperaceæ*, having a hypoderm inside the epidermis, and with the characteristic radial arrangement of the bark-cells, of which the innermost layer, as usual, is differentiated as an endodermis. This endodermis shows, however, a very peculiar development, since the cells, which are exceedingly thin-walled, are stretched radially, as shown in our figure 19. The pericambium is, also, here interrupted by protohadrome, and there are five distinct groups of leptome in alternation with five large vessels, while the innermost part of the root is occupied by fundamental tissue. The root of *F. squarrosa* shows a much weaker structure, since the bark-parenchyma shows many lacunes on account of the radial collapsing of the cell-walls. The cells of the endodermis (*End* in fig. 16) are of normal shape and slightly thickened. A large vessel occupies the center of the root, and tannin-reservoirs were observed in the epidermis as well as in the outer bark-parenchyma.

We see from this brief anatomical sketch that there are several structural characters, by which these two *Fuirena-*

species may be distinguished, although their morphological characters are so prominent as to leave the anatomical distinction unnecessary. But it is, nevertheless, quite interesting to compare their structure in order to ascertain whether there may be some connection between the structure of their tissues and the character of the climate and soil wherein they grow. *Fuirena scirpoidea* has several features in common with some of the most pronounced desert-plants, viz: the reduction of the leaf-blades in contrast to the other species of the genus. It grows in dry, sandy soil and is a very common plant in subtropical Florida. The anatomy of its almost leafless stem shows us a well differentiated palissade-tissue in the bark, thus the stem has taken the function of the leaf; the very thick-walled epidermis is another character by which *F. scirpoidea* approaches itself to the desert plants, e. g., *Panicum turgidum*, as described in Volkens' excellent work upon desert-vegetation (l. c.). We must not, however, consider our *Fuirena* as an exception from most of the *Cyperaceæ* because its leaf-blades are not developed; this very same external structure is, as we remember, very common in species of *Scirpus*, *Eleocharis* and in many *Juncaceæ*. But these almost leafless species grow always in wet soil, in marshes, etc., while our *Fuirena* prefers the dry sand, although not entering in the "Scrub" vegetation, which to a certain extent constitutes a desert-vegetation in Florida.

The anatomical characters are, otherwise, to be observed in the root, viz: the peculiar endodermis in *F. scirpoidea*, the lacunes in the bark in *F. squarrosa*, while the leaf shows us a dense hairy covering and very prominent stomata in *F. squarrosa* in contrast to *F. scirpoidea;* the stem of *F. scirpoidea* with its firm structure and the bark developed as palissade-tissue is very different from the weak stem of *F. squarrosa* with its large lacunes.

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EXPLANATION OF FIGURES.

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FIGURE 1 and 1*b*.—Seedlings of *Fuirena squarrosa*. 9 × natural size. (For explanation of the letters see the text.)
FIGURE 2.—Rhizome of *F. squarrosa;* natural size.
FIGURE 3.—Part of figure 2, enlarged.
FIGURE 4.—Branch of a similar rhizome; natural size.
FIGURE 5.—Same, enlarged.
FIGURE 6.—Clado-prophyllon from the lateral spike-bearing peduncle of *F. squarrosa;* 1½ × natural size.
FIGURE 7.—Rhizome of *F. scirpoidea;* natural size.
FIGURE 8.—Same, enlarged.
FIGURE 9.—Part of a similar rhizome; natural size.

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FIGURE 10.—Prophyllon from the base of a lateral spike of *F. squarrosa;* much enlarged.
FIGURE 11.—Bract from a spike of *F. squarrosa;* 6 × natural size.
FIGURE 12.—Prophyllon of *F. scirpoidea;* much enlarged
FIGURE 13.—Bract of same; 6 × natural size.

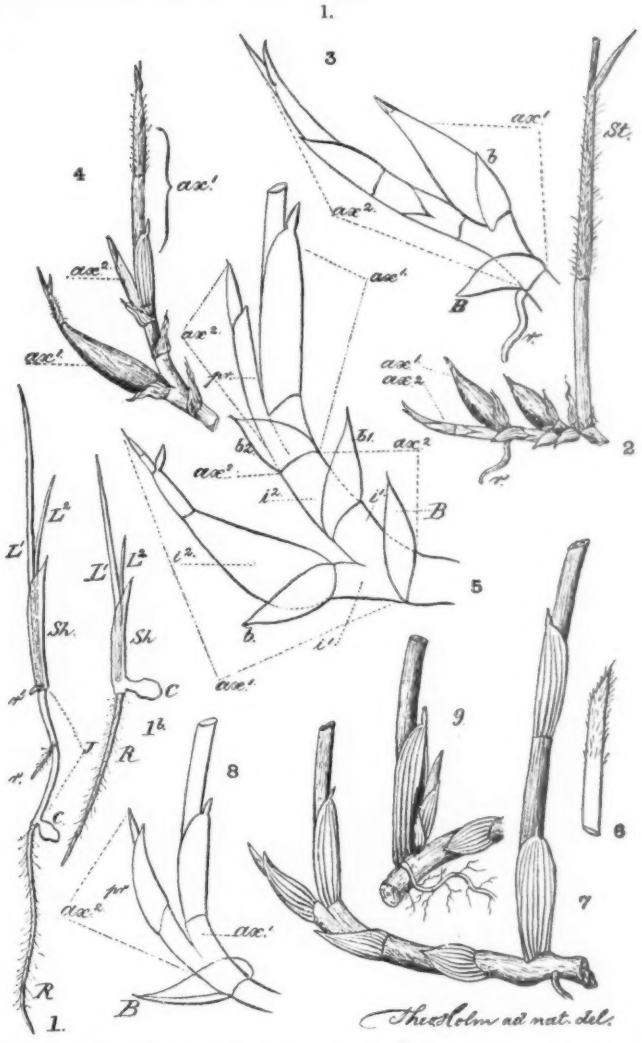


FIGURE 14.—Transverse section of stem-leaf of *F. squarrosa*. Ep. sup. and Ep. inf. = epidermis of the superior and the inferior face; 75 × natural size.

FIGURE 15.—Stoma from the same leaf, transverse section; 320 × natural size.

FIGURE 16.—Transverse section of the root of *F. squarrosa*: *B* = the bark; *End* = the endodermis; *Pr* = the pericambium; *PH* = the protohadrome; 320 × natural size.

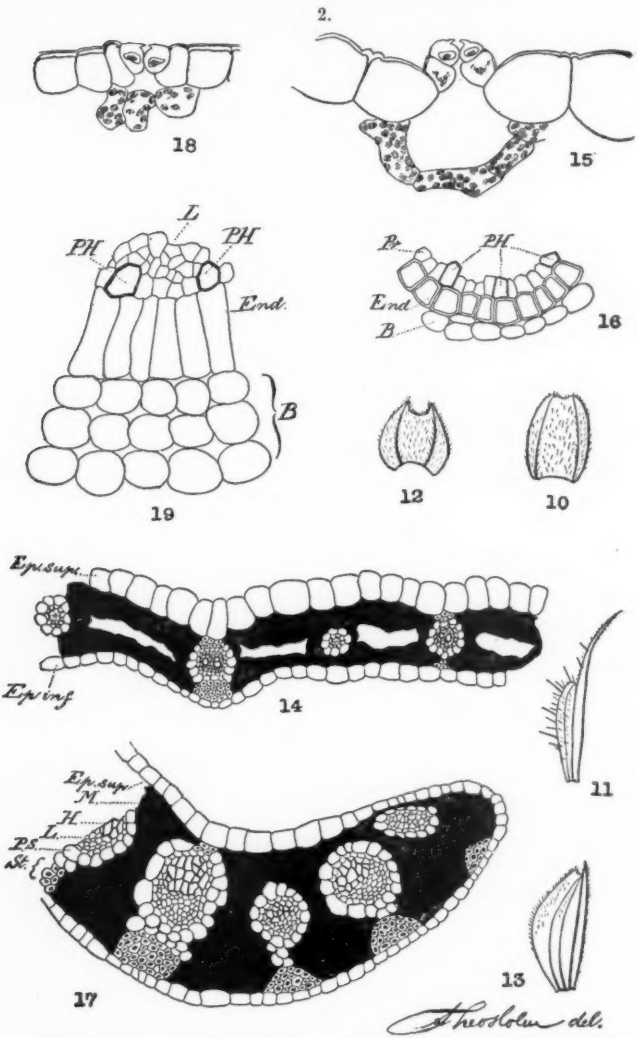


FIGURE 17.—Transverse section of the leaf-blade of *F. scirpoidea*; *Ep. sup* = epidermis of the superior face; *M* = the mesophyll; *H* = the hadrome; *L* = the leptome; *PS* = the parenchyma-sheath; *St* = the stereome; 75 × natural size.

FIGURE 18.—Stoma from the same leaf; 320 × natural size.

FIGURE 19.—Transverse section of the root of *F. scirpoidea*; letters as in figure 16; 320 × natural size.

(The black in figures 14 and 17 indicates the chlorophyll-bearing tissue, the mesophyll.)

ART. IV.—*On the Identity of Chalcostibite (Wolfsbergite) and Guejarite, and on Chalcostibite from Huanchaca, Bolivia;* by S. L. PENFIELD and A. FRENZEL.

Introduction.—In December, 1894, Mr. Thomas Hohmann, mining engineer at Valparaiso, Chili, sent to one of us (Frenzel), for examination, some specimens, from the Pulacayo mine, Huanchaca, Bolivia. Upon one of these were some prismatic crystals of a mineral with metallic luster, which, we were informed by Mr. Hohmann, was found very sparingly, was unknown to him, and might possibly be new or worthy of investigation. As the material was limited, it was decided to identify the mineral, if possible, by its crystalline form, and, upon examination, it was found that the cleavage and some of the prominent crystal forms corresponded to the rare mineral guejarite, described by Cumenge* as having the composition $Cu_2S \cdot 2Sb_2S_3$.

About the same time that this material was sent to us, a second specimen from Huanchaca was received at the *Mineralien Niederlage* at Freiberg, Saxony, and Herr Zinkeisen, director of that institution, on learning that the mineral had been identified as guejarite, sent the specimen to Mr. L. Fletcher of London, and it was purchased for the mineral collection of the British Museum. In order to identify this mineral with certainty, Mr. Fletcher requested Mr. L. J. Spencer, of the Mineral Department of the British Museum, to examine the crystals, when it was found that the forms agreed not only with guejarite, but equally well with chalcostibite (wolfsbergite). An article was accordingly prepared by Mr. Spencer "On Wolfsbergite from Bolivia; and the probable identity of Wolfsbergite and Guejarite,"† but on learning that we were engaged in an investigation of the same mineral, Mr. Fletcher called our attention to the fact that guejarite could not be distinguished crystallographically from chalcostibite. He also requested Mr. Spencer to send the results of his investigation to us, in order that his results might be incorporated with ours, and in subsequent pages it will be shown that guejarite, which has been considered as having the composition $Cu_2S \cdot 2Sb_2S_3$, is really identical with chalcostibite (wolfsbergite), $Cu_2S \cdot Sb_2S_3$.

Chalcostibite from Wolfsberg in the Harz.—Upon material from this locality, the species was first founded in 1835, by Zinken,‡ the mineral being called by him *Kupferantimonglanz.*

* Bull. Soc. Min. de France, ii, p. 201, 1879.

† Read before the Mineralogical Society of London, April 14, 1896.

‡ Pogg. Ann., xxxv, p. 357, 1835.

The composition $Cu_2S \cdot Sb_2S_3$ was established by an analysis by H. Rose,* and the crystals were measured and determined to be orthorhombic by G. Rose,† who identified two prisms and a pinacoid in one zone, but as no terminal faces were observed, the axial ratio could not be fully determined. The name *rosite* was assigned to the species in 1841, by Huot,‡ but on account of its similarity to *roselite*, it has not been generally accepted. In 1847 the mineral was called *chalcostibite* by Glocker,§ and in 1849 *wolfsbergite*, by Nicol.‖ Glocker's name thus antedates Nicol's, and there seems to be no reason for not accepting it, although wolfsbergite is in common use.

Terminated crystals of chalcostibite from Wolfsberg are very rare, and we are indebted to Laspeyres¶ for the only description of them, and for the determination of the axial ratio. In order to show a crystallographic relation between chalcostibite and the similarly constituted minerals zinkenite, $PbS \cdot Sb_2S_3$; sartorite, $PbS \cdot As_2S_3$ and emplectite, $Cu_2S \cdot Bi_2S_3$, the crystals were orientated so as to make the perfect cleavage basal, and the prominent prismatic development parallel to the crystallographic axis *b*.

The forms that were identified by Laspeyres are as follows:

c, 001	*d*, 101	*f*, 011	*p*, 7·14·8**
e, 307	*g*, 201	*q*, 863	*r*, 7·21·27**

The axial ratio was derived from measurements of the pyramid *p*, and was found by Laspeyres to be $a : b : c = 0{\cdot}5283 : 1 : 0{\cdot}6234$, but by giving to *p* the indices 6·12·7 instead of 7·14·8, the axial ratio becomes $0{\cdot}5283 : 1 : 0{\cdot}6364$. Some of the important measurements made by Laspeyres will be found in column I, in the tables on page 34, et seq.

Chalcostibite (guejarite) from Guejar in Spain.—The identity of guejarite as a distinct mineral species had been based upon the following analysis by Cumenge:††

	Found.	Theory for $Cu_2S \cdot 2Sb_2S_3$.
S	25·0	27·0
Sb	58·5	57·8
Cu	15·5	15·2
Fe	0·5	----
Pb	tr.	- --
	99·5	100·0

* Ibid, p. 361.
† Ibid, p. 360.
‡ Mineralogy, i, p. 197.
§ Syn., p. 32.
‖ Mineralogy, p. 484.
¶ Zeitschr. Kryst., xix. p. 428, 1891.
** As will be shown later, 7·14·8 and 7·21·27 should be 6·12·7 and 134, respectively.
†† Loc. cit.

Although the results agree fairly well with the theoretical composition, an analysis in which the determinations are carried out only to half per cents cannot be considered wholly satisfactory for the establishment of a mineral species, and, as neither the method of analysis is given nor any statement concerning the amount of material taken, the results cannot be fairly criticised. As crystals of chalcostibite resemble those of stibnite in color, luster, habit, and cleavage, and, further, as stibnite would probably occur at a locality where chalcostibite is found, as is the case at Wolfsberg in the Harz, it is possible that the material analyzed by Cumenge contained some stibnite, which would account for his failure to obtain the correct formula. It may be noted here that Rammelsberg, in the second supplement of his *Handbuch der Mineralchemie*, p. 54, 1895, places an interrogation after the formula of guejarite.

The crystallization of the mineral was determined as orthorhombic by C. Friedel.* The habit is prismatic, with the faces in the prominent zone striated and grading into one another, owing to oscillatory combinations of a series of prisms. Crystals showing terminations are rare. In the position adopted by Friedel, the nearly perfect cleavage in the prismatic zone was taken as b, 010, and the following forms were identified:

b, 010	h, 210	m, 110	d, 013
c, 001	k, 320†	l, 230†	e, 011

In addition to the foregoing, the doubtful forms 410, 310, and 032 are mentioned and likewise two pyramids, $x\,(b \wedge x = 56° 24')$, and $z\,(b \wedge z = 39° 58')$, but the symbols of these latter forms cannot be determined, as only a single measurement is given for each. The axial ratio obtained by Friedel is $a : b : c = 0{\cdot}8221 : 1 : 0{\cdot}7841$.

In order to bring the crystals into the position adopted by Laspeyres for chalcostibite, it is necessary to change the orientation so that the nearly perfect cleavage is basal, c, 001, and the prominent prismatic zone parallel to the crystallographic axis b. Twice the length of Friedel's vertical axis is taken as the unit length of b, and the axial ratio thus becomes $a : b : c = 0{\cdot}5242 : 1 : 0{\cdot}6377$, while that derived from Laspeyres' measurements is $a : b : c = 0{\cdot}5283 : 1 : 0{\cdot}6364$.

In the following table, the forms observed by Friedel are given, together with the indices when transposed to the position adopted by Laspeyres:

* Bull. Soc. Min. de France, ii, p. 203, 1879.

† The forms 320 and 230 are given by Friedel as 730 and 370, respectively.

Guejarite. Position.		Chalcostibite. Position.	Guejarite. Position.		Chalcostibite. Position.
b, 010	=	*c*, 001	*m*, 110	=	*d*, 101
c, 001	=	*b*, 010	*l*, 230	=	*h*, 203
h, 210	=	*g*, 201	*d*, 013	=	*u*, 061
k, 320	=	*i*, 302	*e*, 011	=	*t*, 021

At the conclusion of his article, Friedel calls attention to the close similarity in the angle of his prism, $m \wedge m = 101° 9'$, with that of the chalcostibite prism 101° 0′ measured by Rose.

In the Brush collection at New Haven, there is a specimen of chalcostibite from Guejar, which was presented by Professor Groth of Munich. It is a fragment of a crystal, without terminal planes, and in appearance it agrees exactly with the description of guejarite given by Friedel. However, in order to make sure of its identity with the material described by him, it was carefully measured, with the results which will be found in column IV in the table on page 34. The specimen weighed a little over one gram, and the specific gravity was found to be 4·959. Cumenge gives 5·03.

Professor Groth very kindly responded to a request to supply us with some of this rare material for a chemical analysis, and he also furnished measurements of a crystal with terminal planes, belonging to the Munich collection. These measurements were made by Mr. Schott, and are given in column V on page 34. The habit of this crystal is shown in fig. 1.

1.

Requests for material were also sent to Professor Freidel and Mr. Cumenge, and they were able to supply us with some of the original mineral from Guejar investigated by them. That received from Professor Friedel was a small fragment of a crystal, weighing 0·108 gram, which corresponded in every particular with that given to us by Professor Groth. Before using it for analysis, however, it was carefully measured, with the results which are given in column III on page 34. The material supplied by Mr. Cumenge consisted of small, finely striated crystal fragments which were not adapted for measurement. They weighed 0·428 gram, and, before subjecting them to analysis, each crystal was tested for copper so as to make sure that there were no stibnite crystals amongst them.

The results of the analyses (by Frenzel) of the specimens received from Professors Groth and Friedel, and Mr. Cumenge, are given below in the columns I, II and III respectively.

Specific gravity 4·96. I.			Ratio.		II.	III.	Theory for $Cu_2S.Sb_2S_3$.
S.	26·28 ÷ 32	=	·821	4·00	S	26·12	25·87
Sb	48·86 ÷ 120	=	·407	1·995	Sb 48·50	48·44	48·50
Cu	24·44 ÷ 126·8	= ·193	·202	0·995	Cu 25·92	25·23	25·63
Pb	·58 ÷ 207	= ·002			Pb	·32	....
Fe	·42 ÷ 56	= ·007			Fe	·49	....
					Zn	·18	....
	100·58					100·78	100·00

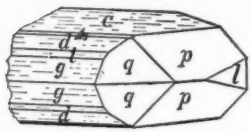
In the first analysis the ratio of $S:Sb:(Cu_2+Pb+Fe)$ is almost exactly $4:2:1$, which is that demanded by the chalcostibite formula $Cu_2S.Sb_2S_3$. The results of the second and third analyses are almost identical with those of the first, so we are thus enabled to establish beyond all doubt the identity in chemical composition of guejarite with chalcostibite.

Chalcostibite from Huanchaca, Bolivia.—On the specimen sent to us by Mr. Hohmann, the chalcostibite occurred as prismatic crystals averaging about 1^{mm} in diameter and 2^{mm} in length, which were attached to a gangue of quartz and pyrite vein material. Some massive tetrahedrite was also present, but the chalcostibite crystals were not found directly upon it. Although the crystals were isolated and quite numerous, only a few were implanted so that they could be removed and used for measurement. Doubly terminated ones were not observed. The crystals are quite highly modified, and the forms that have been identified are given in the following table, where those which are new are indicated by an asterisk:

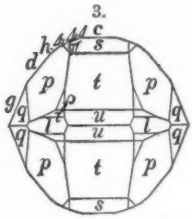
c, 001	*h*, 203*	*t*, 021	*r*, 133*
l, 130*	*d*, 101	*u*, 061	π, 265*
Δ, 209*	*i*, 302*	*q*, 863	ρ, 263*
Δ_1, 207*	*g*, 201	*p*, 6·12·7	σ, 4·12·5*
Δ_2, 205*	*s*, 065*	μ, 136*	τ, 261*

The large development of the pyramids *p* and *q*, whose indices are complicated, corresponds almost exactly with the description given by Laspeyres of the occurrence of the same found on the crystals from Wolfsberg. These pyramids were free from striations and vicinal developments, and gave excellent reflections. A few crystals were observed which have the habit represented in fig. 3, by a projection upon the pinacoid 010. All the pyramidal forms given in the foregoing table were observed upon a single crystal of this habit, but, of the faces in the zone between *c* and *l*, all of which were quite small, μ, ν and σ are not represented in the figure.

2.



3.



The axial ratio given below was derived from exceptionally good measurements of the pyramid *q*, 863.

$$863 \wedge \bar{8}63 = 126° 21'$$
$$863 \wedge 86\bar{3} = 138° 21'$$
$$a : b : c = 0{\cdot}5312 : 1 : 0{\cdot}63955$$

Laspeyres' measurements yield 0·5283 : 1 : 0·6364
Friedel's measurements yield 0·5242 : 1 : 0·6377

A list of the measured angles will be found in column VI in the tables on page 34, et seq.

Although the amount of material was limited, by careful selection a sufficient quantity of the pure, crystallized mineral was obtained for a chemical analysis, which was made by Frenzel, and gave the following results, corresponding with the theory demanded by the chalcostibite formula:

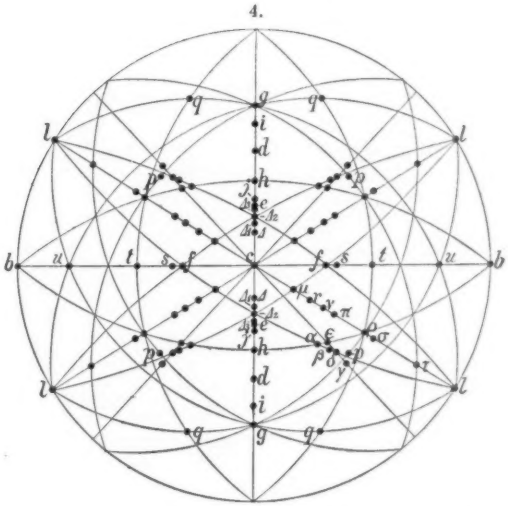
	Found.	Theory for $Cu_2S \cdot Sb_2S_3$.
S	26·20	25·87
Sb	48·45	48·50
Cu	24·72	25·63
	99·37	100·00

Mr. L. J. Spencer gives the following description of the chalcostibite specimen from Huanchaca, belonging to the British Museum. The small, bright, blade-shaped crystals of chalcostibite occur upon a specimen consisting mostly of massive and crystallized quartz, pyrite and tetrahedrite. The chalcostibite crystals are flattened parallel to the pinacoid *c*, 001, and are elongated and striated parallel to the crystallographic axis *b*. They are sometimes terminated at the ends by unsymmetrically developed, narrow, pyramidal planes, but more often by dull rounding surfaces approximating in position to the pinacoid 010. The forms that were observed are given in the table below, those which are new being indicated by an asterisk:

η, 205	*g*, 201	γ, 474*
i, 302	*a*, 233*	δ, 475*
d, 101	β, 354*	ϵ, 476*

The measurements obtained by him will be found in column VII in the tables on page 35.

Summary of the crystallographic investigations.—The following table includes all the forms which have been identified



on chalcostibite, and their distribution is shown by the spherical projection, fig. 4:

b, 010	Δ_3, 205	f, 011	μ, 136	τ, 261
c, 001	e, 307	s, 065	r, 134	α, 233
l, 130	j, 102	t, 021	ν, 133	β, 354
Δ, 209	h, 203	u, 061	π, 265	γ, 474
Δ_1, 207	d, 101	q, 863	ρ, 263	δ, 475
Δ_2, 103	i, 302	p, 6.12.7	σ, 4.12.5	ϵ, 476
	g, 201			

All investigators call attention to the striated character of the crystals in the direction of the crystallographic axis b, and, owing to the difficulty of always obtaining reliable measurements, there may be uncertainty in the identification of some of the forms in the zone 100:001. The only forms which have been identified as prominent ones in this zone are h, d, and g. The prominent development of the pyramids p and q with such complicated indices as 6·12·7 and 863, respectively, on crystals from both Wolfsberg and Huanchaca, is certainly very unusual, and there seems to be nothing gained by giving to one of these forms simpler indices, since that would add very much to the complexity of the remaining forms.

In addition to the perfect basal cleavage, traces of cleavages parallel to the pinacoids 100 and 010 were observed.

In the succeeding tables, the calculated values are derived from the axial ratio $a:b:c = 0{\cdot}5312:1:063955$, and the measurements made by various investigators are indicated by Roman numerals placed above the columns, as follows:

I. Laspeyres. Crystals from Wolfsberg in the Harz.
II. Friedel. Crystals from Guejar in Andalusia.
III. Penfield. Fragment of crystal from Guejar, received from Prof. Friedel.
IV. Penfield. Fragment of crystal from Guejar, received from Prof. Groth.
V. Schott. Terminated crystal from Guejar, belonging to the Munich collection.
VI. Penfield. Crystals from Huanchaca, Bolivia.
VII. Spencer. Crystals from Huanchaca, Bolivia.

Measurements from the base c, 001 on to faces in the zone 001 : 100.

	Calculated.	I.	II.	III.	IV.	V.	VI.
$c \wedge \Delta$, 209	14° 59′						14° 10′
$c \wedge \Delta_1$, 207	18 59						17 40
$c \wedge \Delta_2$, 103	21 52			21° 55′	22° 21′		
$c \wedge \Delta_3$, 205	25 43						25 55
$c \wedge e$, 307	27 17½	27° 12′			27 11		
$c \wedge j$, 102	31 3			31 3			
$c \wedge h$, 203	38 45		39° 58′	38 45	38 46	38° 51′	37
$c \wedge d$, 101	50 17	51 22	50 34½	50 32	50 25	50 18	50 42
$c \wedge i$, 302	61 1½		62 50				61 45
$c \wedge g$, 201	67 27	66 28	67 39	67 8	67 22	67 24	67 24

To the foregoing may be added the measurements of Rose $c \wedge d = 50° 30′$ and $c \wedge g = 67° 36′$, and the following by Spencer: $c \wedge \Delta_3 = 25° 49′$ (mean of 25° 51′, 25° 55′, 25° 51′ and 25° 35′) and $c \wedge i = 63°$, 63° and 63° 13′. These last measurements by Spencer and one given by Friedel, $c \wedge i = 62° 50′$, may indicate the existence of a form 805 ($001 \wedge 805 = 62° 34′$) instead of the more probable one *i*, 302.

Measurements obtained from faces in the zones 100 : 010 and 010 : 001.

	Calculated.	I.	II.	V.	VI.
$l \wedge l$, $130 \wedge \bar{1}30$	64° 13′				64° 22′
$c \wedge f$, $001 \wedge 011$	32 36	32° 21′			
$f \wedge f$, $011 \wedge 01\bar{1}$	114 48	116 31			
$s \wedge s$, $065 \wedge 06\bar{5}$	104 59½				105 24
$c \wedge t$, $001 \wedge 021$	51 59		51° 54′		
$t \wedge t$, $021 \wedge 02\bar{1}$	76 2				76 21
$c \wedge u$, $001 \wedge 06\bar{1}$	75 23½		75 23	75° 24′	
$u \wedge u$, $061 \wedge 06\bar{1}$	29 13				29 32

Measurements obtained from pyramidal faces.

		Calculated.	I.	VI.	VII.
$q \wedge q$,	$863 \wedge \bar{8}63$	126° 21′	126° 31′	126° 21′*	
$q \wedge q$,	$863 \wedge \bar{8}6\bar{3}$	138 21		138 21*	
$q \wedge g$,	$863 : 86\bar{3}$	32 16½	32 18	32 16	
$p \wedge p$,	$6{\cdot}12{\cdot}7 \wedge \bar{6}{\cdot}12{\cdot}7$	69 38	69 49	69 34	
$p \wedge p$,	$6{\cdot}12{\cdot}7 \wedge \bar{6}{\cdot}12{\cdot}\bar{7}$	105 19		105 16	
$p \wedge p$,	$6{\cdot}12{\cdot}7 \wedge 6{\cdot}12{\cdot}\bar{7}$	67 11	67 18½	67 11½	
$c \wedge \nu$,	$001 \wedge 136$	20 41		20 18	
$c \wedge r$,	$001 \wedge 134$	29 31½	30 2½		
$f \wedge r$,	$011 \wedge 134$	16 40½	16 22		
$d \wedge r$,	$101 \wedge 134$	40 45⅓	40 32½		
$c \wedge \nu$,	$001 \wedge 133$	37 3		36 45	
$c \wedge \pi$,	$001 \wedge 265$	42 11		41 46	
$c \wedge \rho$,	$001 \wedge 263$	56 29		56 12	
$c \wedge \sigma$,	$001 \wedge 4{\cdot}12{\cdot}5$	61 6½		61 8	
$c \wedge \tau$,	$001 \wedge 261$	77 33		77 32	
$c \wedge a$,	$001 \wedge 233$	45 44½	---- ----	----	46°
$\Delta_2 \wedge a$,	$205 \wedge 233$	29 19½			30
$c \wedge \beta$,	$001 \wedge 354$	50 20			50 28′
$\Delta_2 \wedge \beta$,	$\bar{2}05 \wedge 354$	71 2			71 9
$d \wedge \beta$,	$\bar{1}01 \wedge 354$	92 2			92 1
$c^0 \wedge \gamma$,	$001 \wedge 474$	58 41			58 43
$\Delta_2 \wedge \gamma$,	$205 \wedge 474$	42 18½			42 3
$d \wedge \gamma$,	$101 \wedge 474$	35 34			34 53
$c \wedge \delta$,	$001 \wedge 475$	52 45			52 25
$c \wedge \epsilon$,	$001 \wedge 476$	47 37			45 to 47°

In the preceding tables, many of the measurements show considerable variation from the calculated values, which might be expected, owing to the striated character of some of the faces and the small size of others. On the other hand, the measurements from the best and most prominently developed forms, *h*, *d*, *g*, *u*, *q*, and *p*, show a very close agreement with the calculated values, and it is believed that the axial ratio which we have established is more accurate than those given by other investigators.

It is probable that the pyramid *x* mentioned by Friedel ($c \wedge x = 56° 24'$) is *p*, 6·12·7 ($c \wedge p$ calculated = 56° 24½′), which is prominently developed on the crystals from Wolfsberg and Huanchaca.

In conclusion, we take great pleasure in expressing our thanks to Professors Friedel and Groth, and Messrs. Cumenge, Hohmann, Spencer, Schott and Fletcher, who have rendered valuable assistance by supplying us with material for this investigation and information concerning the mineral.

Mineralogical-Petrographical Laboratory,
Sheffield Scientific School, February, 1897.

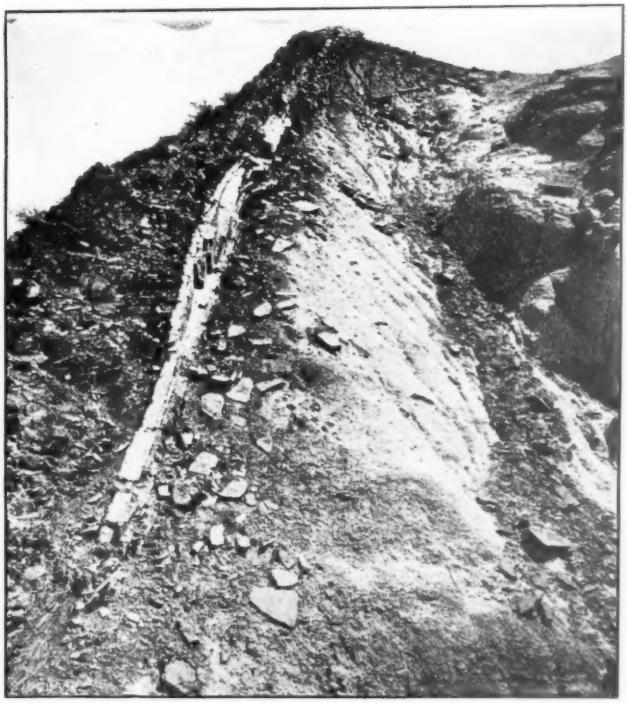
ART. V.—*An Interesting Case of Contact Metamorphism;* by H. W. FAIRBANKS.

BLACK Mountain is the highest peak of the El Paso range, a spur of the Sierra Nevada mountains extending easterly into the Mojave desert. The mountain owes its name to the mantle of dark lavas which covers it. The underlying rocks constitute a part of an extensive series of sedimentary beds exposed for many miles along the northern slope of the El Paso range. They consist of sandstones, clays and conglomerates and contain in places much fragmental volcanic material as well as occasionally interstratified flows. Last Chance gulch and its tributaries drain the western slope of Black Mountain and in the cañons the character of the sedimentary beds, as well as their relation to the volcanic flows, is often finely shown. The sedimentary beds here have a light yellowish or pinkish color and exhibit in places a finely banded appearance. In the field they were thought to be wholly of volcanic origin, but a microscopic examination revealed the fact that the light-colored paste in which the more distinct fragments were embedded consists of an amorphous kaolin-like substance. The small partly-rounded pebbles and grains appear to be of many kinds, but those of a volcanic nature predominate.

The strata have been considerably disturbed and faulted, and in one of the cañons have been intruded by two dikes. One of these has a diameter of less than one foot while the other is 14 feet across. The larger one cuts vertically through the sedimentary rocks which dip at an angle of about 25 degrees. This dike appears very fine-grained, but a microscopic examination shows that it is holocrystalline. The feldspar is probably labradorite and occurs in long laths. The augite has a pale brown color and gives an ophitic structure to the rock. Abundant grains of a reddish color and presenting the appearance of having resulted from the alteration of olivine are scattered through the rock. Owing to the absence of a glassy base the rock is then an olivine diabase. The surface of the outcrop is quite decomposed and weathers away as rapidly as the soft and slightly tufaceous beds.

The remarkable feature connected with the intrusion is the striking manner in which the adjoining rock has been metamorphosed. The thickness of the band of altered tufa is about two feet where it is best exposed. The light colored-soft rock has been baked to a dark hard and very firm one, the slabs of which give forth a ringing sound when struck. A microscopic examination does not reveal any new minerals, but only the fact that the alteration has brought out more clearly the vol-

canic nature of the most of the fragments. The metamorphosed layer weathers out more strongly, as the photograph shows, than either the dike or the unaltered tufa, forming a prominent and sharply defined band extending up the side of the cañon.



Contact metamorphism in the El Paso range, California. The soft tufa lies on the right of the picture, the slaty contact zone in the middle, the diabase dike on the left.

In addition to the pronounced manner in which the rock has been baked there is another striking feature. The hardened layer is not massive, but on the contrary, breaks up into thin and regular slate-like slabs parallel to the wall of the dike. The photograph shows the main lines of fissility and the slabs broken off and strewn over the side of the cañon. An examination of any one of these slabs shows that it also is thickly penetrated by fine parallel seams which are slightly irregular and discontinuous, but which under the action of the weather

would develop into further parting planes. Where these cracks pass through the larger pebbles the latter do not appear to be faulted in the least, so that we cannot attribute their origin to the action of a shearing stress. The most probable explanation which has occurred to the writer is that the partings are due to contraction on cooling. This theory would explain the local irregularities as well as the general parallelism with the dike.

Berkeley, California.

ART. VI.—*The Tin Deposits at Temescal, Southern California;* by HAROLD W. FAIRBANKS.

Introduction.—Several years ago, shortly prior to the final suspension of work upon the Temescal tin deposits, the writer was given exceptional facilities for a careful examination of the mine and the country immediately surrounding it. Subsequently a brief description was published,* but owing to the political importance of the question at the time no thorough report was attempted. Descriptions of the tin veins occurring here have been given by Blake† and Hanks,‡ although little has been published concerning the conditions under which the veins occur and the nature of the ore bodies. In the present paper the writer will add to what is already known, a more detailed description of the veins and the country in which they are found. The report of Hanks referred to above contains an outline of the history of the discovery and the excitement following it, the purchase of the old Mexican grant and the final development by the English company, so that this part of the subject will not be touched upon.

General Geology of the District.—The Temiscal tin mine is located in the northwestern portion of the San Jacinto grant about five miles southeast of South Riverside. This portion of the grant consists of rolling hills having an elevation of nearly 1,000 feet, and formed of a great variety of rocks. To the west, separated by the Temescal valley filled with late Miocene sediments, is the Santa Ana range, the most striking topographic feature of the region. It is high and steep, contrasting strongly with the rolling though sometimes quite mountainous country to the northeast. Its elevation is doubtless due to a great fault line, the northern portion of which passes through the Temescal valley. Immediately adjoining the valley on the east is a more or less connected strip of highly metamorphosed rocks associated with porphyries, but the most of the country in that direction is granite.

The tin deposits lie nearly in the center of a rudely semicircular area of granite about two miles in diameter and connected on the east with the great body of similar rock extending indefinitely in that direction. The sedimentary rocks along the edge of the granite area consist of quartzite, mica schist and conglomerate of unknown age. A part at least of the slates and limestones of the Santa Ana range are

* XIth Report of the State Mining Bureau, p. III.
† Mineral Resources of the United States, 1883–84, p. 614.
‡ IVth Report of the State Mining Bureau, p. 120.

Carboniferous, but further than that we have no information. Extensive bodies of porphyry also border the granite. They vary much in appearance, in some places being of a grayish color and almost devoid of distinct crystals, but more generally the rock presents a groundmass almost black in color in which are sprinkled white feldspar crystals and more rarely those of quartz. It is difficult to say which is the older, the granite or the porphyry. In the neighborhood of the junction both rocks change their character somewhat, although each is distinct. With perhaps one exception, none of the fine-grained granitic dikes abundant in the coarse granite were noticed penetrating the porphyry, but there are bunches and dike-like protrusions of the latter in the granite near the contact.

The granite is distinctly intrusive in the metamorphic rocks, as bunches of it project up through them here and there. The granite varies considerably in texture although the main body has a uniform composition. Macroscopically it shows two kinds of feldspar, one a pale brownish color and the other white, abundant quartz and a small amount of the dark silicate. Under the microscope it is seen to consist of plagioclase, orthoclase, and quartz in nearly equal proportions, with a much less amount of biotite mica. Towards the outer edges of the granitic boss in which the mine is situated are numerous dikes of a very fine-grained granite consisting almost wholly of quartz and orthoclase in interlocking grains. The proportion of quartz seems to be greater in some of these dikes than in the coarse granite to which they are genetically related.

The Vein System and Tin Deposits.—The semicircular area of granite and portions of the adjoining porphyry have been fissured in a general northeast and southwest direction along almost innumerable lines and a black vein matter deposited. The veins are generally small, varying from one-fourth to a few inches in thickness, but in the case of the main tin-bearing vein an enormous size is reached at Cajalco hill. As the hill is approached the veins become larger, and finally culminate in this elevation, which is about 300 by 250 feet in diameter at the base. The veinstone of which it is mostly composed rises in prominent and bold croppings. With one or two unimportant exceptions the material of which this as well as the other veins is formed consists wholly of tourmaline and quartz, with which the tin ores are locally associated. The larger veins, and the Cajalco in particular, are very irregular in size, sometimes appearing to be mere bunches in the granite. A few hundred feet northeast of the hill the vein has narrowed to 6 or 8 feet, and it is here that the large body of tin was first discovered and the main shafts sunk.

A slide prepared from one of the smaller veins, which in the

hand specimen appeared to consist wholly of tourmaline, showed bunches of tourmaline crystals radially arranged and embedded in interlocking quartz grains. The crystals are recognized as tourmaline by the hexagonal cross section, parallel extinction, polarization and frequent presence of fibrous terminations, although the terminal crystal faces are sometimes present. In the most of the sections prepared the tourmaline appears to be exceptionally opaque, sometimes the border is opaque while the center is feebly translucent. With the blowpipe the material fused easily with slight intumescence and became magnetic. The reaction for boron was pronounced.

The large Cajalco vein consists of tourmaline and quartz in almost equal proportions. This aggregate breaks up quite easily, as it is porous, the spaces being lined with drusy crystals of both components. The deposits have evidently been formed in fissures through a gradual replacement of the granite walls. Judging from an examination of the seam-like veins the silicates appear to have been attacked easier and removed first. In places the larger veins seem to blend into the granite and it was at first thought that some of the quartz might be a remnant of the granite, as it is rarely if ever segregated in bunches. A microscopic examination showed that this view was undoubtedly false, as the grains interlock in a different manner from those in the granite, and in addition contained fluid and liquid inclusions. The relative proportions of quartz and tourmaline in the Cajalco vein are so constant that it presents a uniform appearance. Although the mine reports speak of the occasional presence of arsenical pyrites and copper, nothing of the kind came under the observation of the writer. The bunches in these veins, and especially the enormous one forming Cajalco hill, could have been formed in no other way than by replacement, although it is difficult to conceive of its having taken place on such a large scale.

With the earlier reports upon this property nearly all the veins were considered tin-bearing, but at the time the writer made the examination shortly before the mine closed, after diligent prospecting the company had succeeded in finding traces of tin in only one or two veins besides the one worked. Tunnels had also been run into Cajalco hill, but in this great body of vein matter nothing was found. The narrower portion of the vein to the northeast furnished all that was ever milled. At the time of the examination the vein had been opened to a depth of 180 feet by two working shafts, exposing the vein horizontally for 300 feet. Here the vein has a width of 8 feet or less. The main ore body occurs in the center of the mine between the two shafts and extends down on the dip of the vein. The tin oxide is distributed either through the

vein matter or in stringers and bunches. In the latter case it is sometimes found in nearly pure condition. The average of the ore milled was however only about 5 per cent of the oxide. Seams of clay are generally found on or near the sides of the vein, showing some movement since the deposition took place. The walls are quite irregular and sometimes bunches of granite are found wholly inclosed in the vein. The analysis of the ore made by Genth, and quoted by both Blake and Hanks, shows silicic acid 9·82 per cent, tungstic acid ·22, oxide of tin 76·15, oxide of copper ·27, oxides of iron and manganese, lime and alumina 13·54. This must have been an exceptionally pure specimen and wholly free from tourmaline.

The tin ore occurs in two forms; the more important and common variety is either massive and of a brownish color, or in clear reddish brown crystals lining cavities; the less common variety is that of "wood tin," which appears uncrystallized and in the form of thin layers.

It is not known to the writer whether the ore body which was being followed down finally ran out or not, but at any rate it appears that it was unprofitable to work. The great richness of the ore in places is one of the remarkable features of this deposit when compared with most of the other known occurrences of tin. Another remarkable fact is the great size of the main vein as shown in Cajalco hill and its uniformity and simplicity of composition. It appears that the contents of the veins represent the entire replacement of the granite bordering what were originally narrow fissures. The agent which accomplished this was probably heated water carrying various minerals in solution, the economically valuable one, tin, being deposited only in places under exceptional conditions.

ART. VII.—*Additional Notes on the Outlying Areas of the Comanche Series in Oklahoma and Kansas;* by T. WAYLAND VAUGHAN.

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I WAS enabled during the past summer, while working under the direction of Mr. R. T. Hill, to study some areas of the Comanche formations in Kansas and Oklahoma, that have not been described in the literature pertaining to the region. I was also able to visit a locality reported by Cope from near old Camp Supply, and what is probably the original locality from which Marcou obtained the types of his *G. pitcheri* (= *G. navia* Hall, *G. rœmeri* Marcou, *G. forniculata* White). Marcou's were the first observations made in the region;* Cragin† has published numerous papers, and St. John‡ and Hay§ have made lesser contributions. Professor E. D. Cope‖ has published some notes on beds near old Camp Supply. Mr. R. T. Hill¶ has given an extended review of the work that has been done in the whole region, and has published the results of a very careful study of the vicinity of Belvidere. The most recent contribution is that of Professor C. S. Prosser.**

The areas of the beds belonging to the Comanche Series, in Kansas, Oklahoma, Trans-Pecos, Texas, and New Mexico, have been denominated "Outlying Areas" by Mr. Hill because the connection between them and the main area of the Lower Cretaceous in Texas has been destroyed by erosion, or the beds in the intervening areas buried beneath the Plains Formation. There are great lithologic differences between the beds of the "Outlying Areas" and those of the main area: the most conspicuous is the entire absence of chalky formations in the former.

For the portion of the Comanche Series, exposed near Belvidere, the names Belvidere beds†† may be used. There are

* Geology of North America, pp. 22, 26, 27, 38, 39, 1858.

† Bulletin of the Washburn College Laboratory, vol. i, No. 3, pp. 85–91, 1885; vol. ii, No. 9, pp 33–37, February, 1889; vol. ii, No. 10, pp. 65–68, December, 1889; vol. ii, No. 11, pp. 69–80, March, 1890; American Geologist, vol. vii, No. 3. pp. 179–181, March, 1891; vol. xiv, pp. 1–12, July, 1894; vol. xvi, pp. 162–165, September, 1895; and pp. 357–385, December, 1895; Colorado College Studies, Fifth Annual Publication, pp. 49–73, 1894.

‡ Fifth Biennial Report, Kansas State Board of Agriculture, Part II, pp. 132–152, Topeka, 1887.

§ Bull. 57, U. S. Geol. Survey, 1890. Geology and Mineral Resources of Kansas, pp. 12, 13, Topeka, 1893.

‖ Proceed. Acad. Nat. Sci., Phila., for 1894, pp. 63–68.

¶ This Journal, vol. l, pp. 205–234, September, 1895.

** Univ. of Kansas Geol. Surv., vol. ii, pp. 96–194, 1897.

†† Hill, this Journal, vol. l, p. 211, 1895.

two members of the Belvidere beds, a lower sandstone member, the Cheyenne sandstone of Cragin,* and an upper shale member, the Kiowa shales of Cragin.† The following description of the general features of the section are taken from Mr. Hill's article in this Journal.

IV.	Plains Tertiary	11 ft.
III.	Dakota sandstone	20 "
II.	Belvidere beds:	
	b. Kiowa shales, blue and black shales, with fossils	102 "
	a. Cheyenne sandstone, gradating upward into *b*	71 "
I.	Red beds	300 "

For the details of the section the article by Mr. Hill, previously referred to, Professor Cragin's last contribution to the subject, in the American Geologist for December, 1895, and Professor Prosser's report should be consulted.

The Kiowa shales, in which the marine fossils occur, belong to the Washita division of the Comanche Series, as defined by Mr. Hill. The homotaxial relations of the Cheyenne sandstone are as yet indefinite.

There is no necessity for making further notes on the vicinity of Belvidere, so I shall proceed to describe the other localities and outcrops examined.

Outcrops of the Cheyenne sandstone can be seen in Barber County, about five miles from Sun City on the road to Coldwater, where it is light-colored and cross-bedded, contains clay nodules, and weathers into pillars and pinnacles. The contact between the sandstone and the Red Beds was seen at many places, showing that the former rests upon the deeply eroded surface of the latter. Outcrops of the sandstone were occasionally seen on the divide until the descent into the valley of Mule Creek was made. The approximate elevation of the base of the sandstone on the north side of Mule Creek is 1940 to 1960 feet.

Exposures of the Cretaceous occur in Comanche County, about one mile south and five miles east of the village of Nescatunga, around the head of a draw that runs southward into Nescatunga Creek, at an elevation, as judged by the topographic map, between 2020 and 2040 feet. There are several exposures in this vicinity. The easternmost examined consisted of a few feet of very fine-grained pulverulent, stratified, white or pinkish sand, resting unconformably upon the Red Beds. The more western exposures show that the sands

* Bull. Washb. Coll. Lab., vol. ii, No. 10, p. 65, December, 1889.
† Col. Coll. Studies, 5th Ann. Publication, p. 49, 1894.

are overlain by yellow clays, or dark-colored thinly laminated clay shales. In some instances the sands may be indurated so as to form a hard rock.

Map showing position of outcrops of the Comanche Series: outcrops marked by ×.

In a sandstone layer in the clays, casts of the following fossils were found*:

Tapes belviderensis Cragin?
Undetermined species of *Cardium*, *Nucula*, and *Corbula*.
The *Cardium* may be the one identified with *C. kansasense* Meek by Cragin.

* Mr. T. W. Stanton has furnished me notes on the fossils collected.

The following was observed seven and a half miles south of Coldwater, and two and a half miles north of Avilla:

Thin capping of plains gravel.
Yellow clay, with a thin indurated shell layer near the top, in which *Gryphæa forniculata* White, *Cyprimeria* cf. *texana* Roemer, *Turritella seriatim-granulata* Roemer? and a *Cytherea* were found ..... 5 ft.
A light bluish gray, stiff sandy clay, no fossils ..... 40 "
Deep red sandy clay, the Red Beds.

The town of Avilla is situated in a valley, on the Red Beds, ten miles south of Coldwater. About seven miles south of Avilla are some hills composed largely of black shales, and locally known as Black Hills. This locality has been referred to by Professor Cragin,* but he has not described it. The details as presented by Professor Prosser† differ slightly from those given in the following description of the section:

Capping of plains gravel.
Calcareous, yellow, sandy flags, and clays; about 10 feet from the top is a bed of *Gryphæas* intermediate in characters between *G. tucumcarii* of Marcou and *G. forniculata* of White, 20 feet from the top large slabs of *G. tucumcarii*. 40 feet from the top a stratum of oysters and Anomias. 70 ft.
Yellow clay, some thin sandy indurations ..... 35 "
Indurated layer containing many *Gryphæa forniculata*, *Turritella seriatim-granulata* Roemer?, *Cyprimeria*, etc., very rich in fossils, about ..... 5 "
Paper shales, black ..... 45 "
contain a ledge of brown sandstone 1 ft. thick, 10 ft. above the base.
Yellowish clays ..... 5 "
Contact with the Red Beds—the surface of the latter much eroded; they are composed of deep red somewhat sandy clays.

In some places the basal clays of the Cretaceous are mottled, bluish gray and red on a large scale, being composed of the redeposited Red Beds. In one place a patch of shell agglomerate composed of *Gryphæa forniculata* was seen resting directly upon the Red Beds.

The Cretaceous shales were seen in a good many places high up on the divide, south of Avilla, until the descent into the valley of the Cimarron River was made, some twenty miles southeast of that place on the road to Woodward.

* Bull. Washburn Coll. Lab., vol. ii, No. 11, p. 74, March, 1890.
† Prosser, op. cit., p. 142.

Camp Supply Locality.

I was conducted to the following locality by Mr. J. J. Monahan of Camp Supply.

Section of butte, about three miles west of Camp Supply, on the divide between Wolf and Beaver creeks.

Capping of butte, a shell agglomerate composed almost entirely of Anomia shells. There are also an elongate delicate species of oyster, and a *Gryphæa* that is difficult to determine, as no good specimen was obtained; it is probably *G. tucumcarii* ..... 6 inches.
Yellow calcareous clays, about ..... 15 ft.
Indurated shell agglomerate, containing
Gryphæa tucumcarii Marcou.
Gryphæa forniculata White, very abundant.
Anomia.
Cyprimeria cf. *texana* Roemer.
Gervillia?
Cardium.
Turritella seriatim-granulata Roemer?
Anchura kiowana Cragin?
Schloenbachia.
Sharks teeth ..... a few inches.
Yellow calcareous clays, resting directly on the Red Beds. Near the base of this bed is a thin indurated sandy layer that contains many Turritellas, some oysters, etc. *Gryphæa forniculata* occurs in the clays below the sandy layer, and was seen in one place resting directly upon the Red Beds ..... 40 ft.
In one place a thinly laminated yellow calcareous sandstone was seen resting on the Red Beds.
Thickness of Red Beds to flat along Wolf Creek ..... 140 "

The Cretaceous was seen at several places on this divide and probably forms a continuous capping.

The localities examined by Professor Cope in this vicinity were on the north side of Beaver Creek, between it and the Cimarron.* He says "Our first object was to examine the red bluffs of Permian or Trias, which bound the cañons north and northwest of the post, which form part of the drainage system of the Cimarron. . . . We found that the formation which constitutes the higher levels at the heads of the cañons tributary to the Cimarron is an impure friable calcareous limestone of evidently lower Cretaceous age." The following is a revised list of the species of mollusks collected by Professor Cope:†

* Proceed. Acad. Nat. Sci., Phila., vol. for 1894, p. 64.
† R. T. Hill, this Journal, vol. l, p. 227, 1895.

"*Gryphæa forniculata* White.
Exogyra texana Roemer.
Ostrea subovata Shum.
Ostrea quadriplicata Shum. (variety).
Cucullæa terminalis Conrad.
Plicatula incongrua Cragin.
Trigonia emoryi Conrad.
Trigonia sp.
Turritella seriatim-granulata Roem.
Schœnbachia peruvianus von Buch."

As Professor Cope gives no precise locality for the Cretaceous outcrops, the information furnished by Mr. J. L. Daggitt, a cowboy familiar with the country, may be of interest. He told me that the same kind of a shell bed, that I saw west of Camp Supply, occurred on high places on the divide between Beaver Creek and the Cimarron River on both sides of the Camp Supply and Dodge City, Kansas, cattle trail. The first outcrop is to be seen about five miles north of the former place.

Outcrops in the vicinity of Taloga.

Mr. J. F. Gallup guided me to the localities examined. On the northwest ¼, Sec. 9, T. 19 N., R. 17 W. (I. M.) seven miles north and three miles west of Taloga, there are outcrops of a shell agglomerate, 12 to 18 inches thick, and composed almost entirely of the shells of *Gryphæa forniculata* White. Besides these species there are

Gryphæa tucumcarii Marcou, in the same matrix with the *G. forniculata.*
Cyprimeria cf. *texana* (Roemer).
Protocardia texana Conrad?
Three or four other species of undetermined pelecypods.
Turritella seriatim-granulata Roemer.
Schlœnbachia peruviana von Buch.
Echinoid plates.

This shell limestone, at the place where it was examined, constituted all there was of the Cretaceous. The outcrops occur along the sides of the draw and were deposited against the sides of the Red Beds hills. They occupy an elevation about 100 feet below the top of the divide, which is composed of Red Beds, overlain by an occasional remnantal patch of Plains gravel. According to the barometer readings the Cretaceous outcrops seemed to be about 100 feet above the South Fork of the Canadian, but they may stand higher. A little higher up the draw along which the above described limestone outcrops occur, is an exposure of stiff chocolate-colored sandy

clay, containing carbonaceous particles and resting against the Red Beds. This clay is probably Cretaceous.

On Section 10 of the same township and range, another outcrop of the shell limestone was seen. Mr. H. G. Springston told me that other outcrops occur on sections 7 and 8 of T. 19 N., R. 17 W.

Marcou's Comet Creek locality.

This locality is especially important because it is the original locality at which Marcou found his *Gryphæa pitcheri*, and is the type locality for his *Neocomian*.

Marcou states "I have mentioned two points between Topofki Creek and Anton Chico where the Triassic rocks are covered by more modern formations. The first of these points is upon one of the tributaries of the False Washita river—Comet Creek (latitude 35° 32′ 2″; longitude 99° 14′ 40″)—near our camp No. 31, where upon the heights are found the remains of beds of a limestone filled with shells, which I connect with the *Neocomian* of Europe, or in other words with the Lower Division of the *Cretaceous Rocks*. This limestone is only five feet thick; it is of a whitish gray color, containing an immense quantity of *Ostracea*, which I consider as identical with the *Exogyra* (*Gryphæa*) *Pitcheri* Mort. (Pl. iv, fig. 5, 5*a*, 5*b* and 6) having the closest analogy with the *Exogyra Couloni* of the *Neocomian* of the environs of Neuchatel (Switzerland)."* On page 39 of the Geology of North America, Professor Marcou gives long. 99°, lat. 35° 50′, one of the hills surrounding Comet Creek, as the original locality of his *Gryphæa pitcheri* (not Morton's *G. pitcheri*) = *G. forniculata* (White). There is a discrepancy between these two records of the Comet Creek locality. Marcou's Geological Map of the route† introduces another discrepancy. The following can be obtained from studying what he has written or represented on his map. The locality is not far from Arapaho, it is near the Washita River and is on its northern side. Upon comparing Marcou's map in the Pacific Railroad reports with the present postal route map, it seems very probable that what Marcou called Comet Creek is now known as Barnitz Creek. If Marcou had stated upon which side, east or west, of Camp 31, or upon which side of Comet Creek the locality was, we might be able to rediscover it without great difficulty.

I found eighteen miles north of Arapaho, about two miles south of the D and G county line, an agglomerate composed of *G. forniculata*. Mr. G. T. Dulany, superintendent of schools

* Geology of N. A., p. 17, 1858.

† Vol. iii, Senate Doc., Report Pac. R.R. Expl.

in G. county, directed me to the following locality: about ten miles south of west of Arapaho, Sec. 11, T. 12 N., R. 18 W., on the north side of the Washita River, west of Barnitz Creek. Here there are outcrops of a shell limestone, composed of *Gryphæa pitcheri* Marcou (*G. forniculata* White), imbedded in a matrix of yellow clay, which is often washed out, leaving only shells stuck together. The bed is scarcely two feet thick and forms the tops of small knolls. These patches of the Cretaceous do not occur on the very top of the divide, but on the flanks of the Red Beds hills which rise considerably higher.

Judging from Marcou's map and description, I believe that the above is his original Comet Creek locality. Mr. Dulany informed me that the western bluffs of Panther Creek, southeast ¼, Sec. 12, T. 13 N., R. 20 W., 18 miles west and three miles north of Arapaho, are composed of the *Gryphæa* rock. The rock occurs all along the creek from its mouth to its head.

No outcrops of the Cretaceous were found south of Arapaho.

The studies that have been presented in the preceding, show (1) that the Cheyenne sandstone becomes thinner and disappears to the south of Avilla; (2) that the Kiowa shales rest directly upon the Red Beds south of Avilla; (3) that these shales become thinner to the south and are represented in the vicinity of Taloga and Arapaho only by the bed of *Gryphæa forniculata* a few feet thick, now left as patches in a few places; (4) that south of Camp Supply the lower Cretaceous beds do not occupy the tops of the highest divides, but have been deposited on the flanks of the Red Beds hills, thus showing that the country in the vicinity of Arapaho and Taloga was not completely submerged in Lower Cretaceous time. The Wichita Mountain region was, as has previously been shown,* a promontory projecting westward into the Lower Cretaceous sea which sent an arm northward around its western end. The existence of the Wichita promontory may explain the difference between the "Outlying Areas" of the Comanche Series and the main areas in Central Texas. (5) Marcou's *Gryphæa tucumcarii*, asserted by him to be Jurassic, was found in the same matrix with *his* "Neocomian" *G. pitcheri* (non-Morton) or even in higher beds, thus adding more strength to the chain of evidence by which his "Jurassic" has been proven not only not Jurassic, but that it belongs to Cretaceous beds above his so-called *Neocomian*, which is far above the base of the American Cretaceous.

Washington, D. C.

* Hill, this Journal, vol. l, p. 229, September, 1895.

Art. VIII.—*On Electrosynthesis;* by W. G. Mixter.

[Contributions from the Sheffield Laboratory of Yale University.]

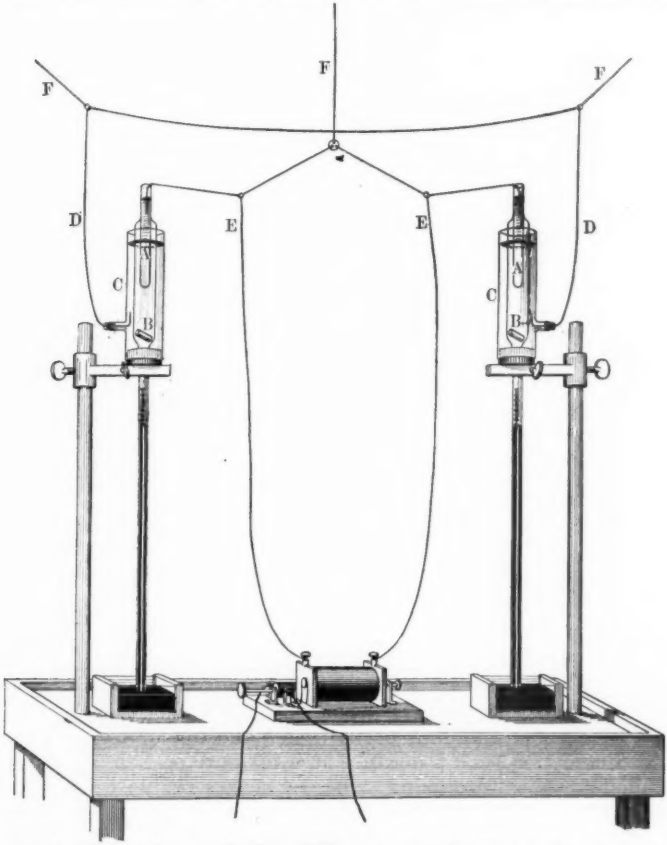
The action of the electric current on compounds, as is well known, usually decomposes them whether they are in solution, in the molten or gaseous state. As an example of the last we have the electrolysis of steam* with the separation of hydrogen and oxygen equal to the volume of these gases evolved by the same current through dilute sulphuric acid that passes in sparks through the steam. The heat of the sparks also decomposes the steam, but this has not prevented the determination of the electrolytic results. Some physicists consider that the molecules of simple as well as compound gases are decomposed by the electrical discharge and that free atoms, or ions, carry the electricity. If this is true, then the primary effect of electricity may be solely electrolytic and the synthetic results may be due to combinations of free ions. Without discussing this now, let it be understood that the term electrosynthesis is applied in this paper to chemical union effected by means of electricity, not, however, by the heat of the discharge. Ammonia, nitric acid, and a few other compounds have been produced in small quantities by the action of electricity, and recently Losanitsch and Jovitschitsch† have made an important addition to our knowledge of electrosynthesis. Their results may be indicated by the equations $H_2O+CO=HCOOH$, $CO_2+H_2O=HCOOH+O$, $CO+H_2=CH_2O$, $CO_2+H_2=HCOOH$, $CO+CH_4=CH_3CHO$. They state that the dark discharge (dunkle Entladung) effects synthesis only, but my observations are that a feeble glow visible only in a dark room causes decomposition as well as combination.

Early last year I observed that feeble sparks in an ozonizing tube with an inner conducting wire did not cause an explosion of acetylene gas under a pressure at which it exploded promptly when the ordinary spark was passed through it. This led to experiments with various forms of electrical discharge in a mixture of two volumes of hydrogen and one of oxygen. It was found that such a mixture at a pressure of 235^{mm} was not exploded in an ozonizing tube, by sparks visible in daylight and giving a distinct snapping noise. The combination was slow. At the pressure given the mixed gases are exploded by the ordinary electric spark, while, as is known, they do not

* J. J. Thomson: Recent Researches in Electricity and Magnetism, pp. 181 and 559.

† Ueber chemische Synthesen mittels der dunkler elektrischen Entladung, Ber. d. deutsch. chem. Gesellscl., xxx, 135.

explode when under a pressure of 70^{mm} or less. Dixon* found that a mixture of cyanogen and oxygen exhibits a similar deportment and that it is exploded by a strong but not by a feeble spark. Hautefeuille and Chappuis† state that hydrogen is indifferent when oxygen is ozonized, and Berthellot‡ found that two volumes of hydrogen and one of oxygen did not combine under the influence of the current (l'effleuve) and that ozone was formed. These observations do not



accord with mine and the different results may be due to different conditions of experiment. The glow discharge in the apparatus described later causes the slow combination of hydrogen and oxygen, during which very little ozone is formed.

* Jour. Chem. Society, xlix, 384.
† Comptes Rendus, xci, 522, 762.
‡ Ann. Chim. et Phys., [5], xvii, 142.

After trying various forms of apparatus, that shown in the figure was adopted. The wires E from the induction coil dip into the tap water in the inner tubes A and the tap water in the jacket tubes C is connected by the insulated wire D. The wires are supported by the insulating cords F, and the standards and clamps are of wood. The eudiometers are placed about three feet apart, it having been found when they were only a few inches apart that an electrical discharge in one sometimes produced a glow in the other from which the conducting wires were removed, and when close together and in series that the results were discordant. Experience also showed that it is necessary to let the apparatus stand some hours before commencing an experiment. A current of 2·2 volts and 1 to 1·6 amperes from one storage cell was used on the primary of the coil, giving a spark in air of 7 to 10 millimeters and of course a much feebler current through the wire D. A current of higher potential discharged perceptibly into the air from the wires E. Two cells were used and the coil was connected at times with only one eudiometer to complete the reaction in order to find the residual gas not entering into combination. The gases were dried by solid potassium hydroxide at B. To absorb carbon dioxide half to one cubic centimeter of a saturated solution of potassium hydroxide was introduced and made to coat the eudiometer four or five centimeters above B. The vapor tension of the solution was too small to interfere with the results. The absorption of water and carbon dioxide was so rapid while the discharge was taking place in the eudiometers that only one or two per cent of the volume of the gases was water or carbon dioxide or both together. This was found by reading the eudiometer when the current from the coil was stopped and again some hours later. With gases at a pressure of 150^{mm} or less a glow about the tube A, visible only in a darkened room, usually appeared on putting the coil in action, while in some cases a stronger current than that described was required to start the glow discharge, but when once started the feeble current gave a fairly constant glow. The discharge between the glass surfaces in the eudiometers was of course alternating and so was the current in the connecting wires and hence not measurable by electrolytic methods. Many experiments were made with the discharge from large metallic electrodes in oxygen and hydrogen at low pressures. Sometimes there was slow combination, but usually the mixture exploded, and hence attempts to use the direct discharge were abandoned. A Wimshurst machine was also tried without success. When connected with the eudiometers described they appeared to act as condensers, the discharge in them being alternating. At some future time I hope to measure the current by electrical methods and to determine the quantity of

electricity causing the combination of gases, and also to determine the conductivity of gases when uniting. Thus far in the work an empirical measure has been used which is the amount of oxygen and hydrogen combining in one eudiometer while gases in the other eudiometer also combined, the same current passing through both eudiometers. The mixture of hydrogen and oxygen used in all of the work was obtained by the electrolysis of dilute sulphuric acid. The following experiments with hydrogen and oxygen in both eudiometers were made to test the method. The reduced volume is calculated for 0° C. and 760^{mm} pressure. The time of the action of the current is given in hours in the column on the left.

Eudiometer No. 3.						Eudiometer No. 1.				
Hours.	Temp.	Pressure.	Observed volume.	Reduced volume.	c. c. of gas combined.	c. c. of gas combined.	Reduced volume.	Observed volume.	Pressure.	Temp.
	14·5	1·3	121	0·2			0·02	118	0·1	14·5
	16·6	190·5	152·7	36·1			34·8	146·8	191·1	16·4
1	16·6	177·5	150·5	33·1	3	3·7	31·1	144·3	173·5	16·6
1	16·6	161·5	148·1	29·7	3·4	4·1	27	141·6	153·5	16·6
1	17	147	145·8	26·6	3·1	4	23	138·7	134	17
*										
	13·6	132·8	142·4	23·7			22·6	137·3	131·3	13·4
1	14·6	119·5	140·4	21	2·7	3	19·6	135·1	116	14·6
1	13·6	103·5	137	17·8	3·2	3·1	16·5	132	99·5	13·6
1	13·6	85	134	14·3	3·5	3·4	13·1	129·2	81	13·6
1	11·6	64·5	131	10·7	3·6	3·5	9·6	126·3	60·5	11·6
1	12	47	127·9	7·6	3·1	3·1	6·5	123·5	42	12
1	12·6	33·3	126·1	5·3	2·3	2·2	4·3	121·4	27·9	12·6
1	13·6	20	124	3·1	2·2	2·1	2·2	119·5	15	13·5
					30·1	32·2				
		Residual gas.					Residual gas.			
	14	4	121·6	0·61			0·58	117	4	14

Eudiometer No. 3.						Eudiometer No. 1.				
Hours.	Temp.	Pressure.	Observed volume.	Reduced volume.	c. c. of gas combined.	c. c. of gas combined.	Reduced volume.	Observed volume.	Pressure.	Temp.
	14	224·5	156·5	44			43	151·2	226·8	14
1	14	204·8	153·6	39·4	4·6	4·7	38·3	148·4	206·3	13·8
1	15·7	188	151·2	35·4	4	4·1	34·2	145·9	188·5	15·7
1	17	172	144·8	31·7	3·7	3·5	30·7	143·7	172·5	17
1	17	158·4	146·4	28·7	3	3	27·7	141·3	158·2	17
1	17	141·1	143·1	25	3·7	3·6	24·1	138·0	141·1	17
1	17·4	118·2	139	20·4	4·6	4·5	19·6	134·9	117·2	17·4
1	17·9	97·4	136·1	16·4	4	3·9	15·7	131·6	96·8	17·9
1	18	74·5	132·8	12·2	4·2	3·8	11·9	128·6	74·8	17·8
1	18	55·5	129·6	8·9	3·3	3·3	8·6	125·6	55·3	18
1	18	37·5	126·8	5·9	3	2·9	5·7	122·9	37·5	18
1	16·6	20·5	124·8	3·2	2·7	2·4	3·3	121	22·2	16·6
					40·8	39·7				
		Residual gas.					Residual gas.			
	15	4·8	120·6	0·72			0·70	116·4	4·8	15

* Passed the current through 3 only for a time to equalize the pressure, then through both for a few minutes and observed the volume later.

The eudiometers were filled with gas for the second experiment without removing the residual gas of the first, namely 0·61 and 0·58^{cc} and the increase of 0·1^{cc} of residual gas in the second experiment shows that almost no ozone was formed. Moreover, the mercury was only slightly tarnished. During half of the time of the first experiment the current was reversed in the primary of the coil with no marked difference in the relative rate of combination in the two tubes. The direction of the current was not changed in the second experiment. The lack of uniformity in the results from hour to hour is only in small part due to errors of observation and is probably owing to leakage of electricity from the wires or its passage over the surface of the glass above the jacket tubes. The marked discrepancies during the first three hours of the first experiment show the liability to error in the method. Leaving out these hours, the results accord fairly and the total amount of combination is 20·6^{cc} and 20·4^{cc} respectively.

It will be observed that the gases in the two tubes were under nearly equal pressures. This is essential, for the higher the pressure the more rapid the combination as shown by the following: the results in each horizontal line were by the same current acting on a hydrogen-oxygen mixture in two eudiometers.

c. c. combined.	Mean pressure.	c. c. combined.	Mean pressure.
6·22	133^{mm}	3·87	73^{mm}
5·42	160	4·39	110
21·95	186	13·3	91
14·43	81	11·25	76

The reason for these results is not apparent and the rate of combination bears no simple relation to the pressure.

Vapor of water, as already mentioned, is electrolyzed by the spark discharge, and it is also dissociated by the feeble glow discharge. Three experiments made with the vapor at low pressures in apparatus like that figured gave small volumes of permanent gas. Hence it may be that some of the water from the oxidation of hydrogen is decomposed, but it is probable that little if any is decomposed in a mixture of gases in which water is constantly forming and which contains on account of rapid drying a very small proportion of water.

In order to determine the ozonizing effect on pure oxygen of the glow discharge, one eudiometer was filled with 36^{cc} (reduced to 0° and 760^{mm}) of oxygen at 193^{mm} pressure and the other eudiometer with 30·6^{cc} of hydrogen and oxygen. A saturated solution of potassium hydroxide and iodide was put into each eudiometer to dry the gases and absorb ozone. A current from two storage cells on the primary of the coil was used for an hour and a half. The oxygen contracted 0·3^{cc}, and

the hydrogen-oxygen mixture 11·2^{cc} (reduced to 0° and 760^{mm}). The light in the oxygen was much feebler than in oxygen and hydrogen. The current was next passed through the oxygen only for two hours and the contraction was 2·2^{cc}.

Carbonic Oxide and Oxygen.

The carbonic oxide used was made by heating a mixture of formic acid and oil of vitriol. Two measures of the gas were mixed over water with one measure of oxygen from pure potassium chlorate. The mixed gases left after exploding and treating with potassium hydroxide less than 1 per cent of gas. The following table contains the observations and results of four experiments.

Hydrogen, 2 volumes. Oxygen, 1 "						Carbonic oxide, 2 volumes. Oxygen, 1 "				
Hours.	Temp.	Pressure.	Observed volume.	Reduced volume.	c. c. of gas combined.	c. c. of gas combined	Reduced volume.	Observed volume.	Pressure.	Temp.
	16	180·5	144·9	32·5			33·2	148·1	180·5	16
2	14·5	147·5	140·7	25·9	**6·6**	**7·9**	25·3	144·4	140	14·5
	15·8	179·8	140	31·3			33·3	145	184·7	15·8
5	16·6	69·5	124·3	10·7	**20·6**	**21·1**	12·2	128	77·5	16·2
	15·9	186	148·7	34·4			32	144·5	178·1	16·2
5	18	94	135 9	15·8	**18·6**	**22·3**	9·7	121·3	65	18·3
	17	1·5	121·3	0·2			0·5	118	3·5	17
	16·4	188	150	35			39·2	149·6	211	16·4
2	16	153	147·3	28	**7**	**8·4**	30·8	146	170	16·5
2	14·7	117·8	140·8	20·7	**7·3**	**9·2**	21·6	138·4	124·8	14·7
2	15·8	82·6	135	13·9	**6·8**	**7·2**	14·4	132	87·6	15·6
2	16	28·2	125	4·4	**9·5**	**10·2**	4·2	122·7	27·2	16
					30·6	**35**				
	20	3·2	122·4	0·5			0·6	119	4·2	18

In the last experiment the air in the eudiometers, 0·2 and 0·5^{cc}, was noted before filling with the gases, and also the residual gas, 0·5 and 0·6^{cc}, when the electric discharge gave no further rise of the mercury in the tubes. The hydrogen-oxygen mixture was in one eudiometer in the first and third experiments and in the other eudiometer in the second and fourth; that is, the arrangement and filling of the apparatus was reversed each time after the first experiment. In all 76·4^{cc} of hydrogen and oxygen and 86·3^{cc} of carbonic oxide and oxygen combined, a ratio of 1 to 1·13.

Glow Discharge in dry Carbonic Oxide and Oxygen.

The eudiometers were filled with a mixture of two volumes of carbonic oxide and one volume of oxygen, the same mixture

as used in the preceding experiments, and phosphorus pentoxide was put into the eudiometers to dry the gases. The apparatus was allowed to stand for two days and then the glow discharge was passed for two hours. The contraction in volume caused by the discharge was in each case 2·5^{cc}, reduced to 0° and 760^{mm} pressure. The initial volumes were 13·1^{cc} and 18·5^{cc} respectively. The results show that dry carbonic oxide and oxygen slowly combine when acted upon by the glow discharge.

Methane and Oxygen.

The methane was made from methyl iodide by the action of zinc and alcohol. For the following experiments one volume of methane and two volumes of oxygen were mixed over water.

Hydrogen, 2 volumes. Oxygen, 1 "						Methane, 1 volume. Oxygen, 2 "				
Hours.	Temp.	Pressure.	Observed volume.	Reduced volume.	c. c. of gas combined.	c. c. of gas combined.	Reduced volume.	Observed volume.	Pressure.	Temp.
	15	13	117	1·9			0·8	120	5	15
	14·3	164·5	119	24·5			28·2	143	157·5	14·3
2	15·5	129·5	118·5	19·1	**5·4**	**7·1**	21·1	139	121·5	15·2
2	16·4	90·5	117	13·1	**6**	**9**	12·1	131	74·5	16
2	18	51	116·5	7·3	**5·8**	**9·5**	2·6	123	17	18
	24	21	116	2·9			1·5	122	10	19
					17·2	**25·6**				
	17	4·5	119·5	0·7			1	117	7	17
	13·3	192·5	148·7	35·9			30·2	120	200·5	13·3
2	14·	159·5	144·3	28·8	**7·1**	**9·9**	20·3	119	136·5	14·4
2	15·6	122·5	138·4	21·1	**7·7**	**11·1**	9·2	118	63·5	16
	17	4·8	120	0·7			2·7	117	19	18·8
					14·8	**21**				
	14	1·5	120	0·2			0·4	116	3	14
	16	203	129	32·6			34·7	144·5	193	16
2	17·1	161·5	126	25·2	**7·4**	**10·3**	24·4	137·3	143·5	17·3
2	16·4	111	122·5	16·9	**8·3**	**11**	13·4	127	85	16·6
	19	2	117	0·3			3·9	118·5	26·5	17
					15·7	**21·3**				

The eudiometers in the first experiment contained 1·9^{cc} and 0·8^{cc} of air and the residual gases at the end of the test were 2·9^{cc} and 1·5^{cc} respectively when the battery gave out. The result shows that the methane and oxygen combined according to the equation

$$CH_4 + 2O_2 = CO_2 + 2H_2O.$$

In the second experiment the residual gas, after the discharge ceased to cause a diminution of volume in the methane-oxygen mixture, was 2·7^{cc}, while in the last experiment the residual gas

was 3·9cc and was found to be chiefly oxygen. This excess of oxygen may be due to leakage of the mixed gases from the gas-holder during the time intervening between the first and last experiment. In the three experiments 47·7cc of hydrogen and oxygen and 67·9cc of methane and oxygen combined, or in the ratio of 1 to 1·42. The ratio in the successive experiments is 1 to 1·49, 1 to 1·43, and 1 to 1·36. The smaller ratios for methane and oxygen in the last two are explained by the presence of an excess of oxygen.

Ethylene and Oxygen.

The ethylene used was made from ethylene bromide by means of a zinc-copper couple and was nearly pure.

Hydrogen, 2 volumes. Oxygen, 1 "						Ethylene, 5·2 c. c. Oxygen, 19·1 c. c.			
Hours.	Temp.	Pressure.	Observed volume.	Reduced volume.	c. c. of gas combined.	c. c. of gas combined.	Reduced volume.	Observed volume.	Pressure.	Temp.
	12·8	126·5	138	22			24·3	138	140	13·3
2	13·7	97 5	134	16·4	**5·6**	**12·4**	11·9	128	74	14
							*6	124	39	18
							Ethylene, 1 volume. Oxygen, 3 volumes.			
	16	131	137	22 3			25·3	140	145	16
2	13	76	129	12·3	**10**	**18·5**	6·8	126	43	13
							*5·2	125	33	14
							Ethylene, 1 volume. Oxygen, 2·5 volumes.			
	16·6	101·8	137·5	17·4			21·1	140	121·3	16
1	17	80	134	13·3	**4·1**	**12·5**	8·6	130·5	53	16·6
							*0·7	124	4·7	20
	16·8	82	131	13·3			19·1	136	113	16·2
1	17·8	62	128	9·8	**3·5**	**10·7**	8·4	128	53	17·8

Three volumes of oxygen are required for the complete oxidation of one volume of ethylene, but in none of the experiments was the gas all oxidized to carbon dioxide and water. In the first experiment with an excess of oxygen 2·5 volumes disappeared to one of ethylene. The residual gas, 5·2cc, of the second experiment was found to be oxygen. The combination of ethylene and oxygen in the third was very nearly in the proportion of 1 to 2·5 volumes. Doubtless some acetic acid was formed, as no oxalic or formic acid was found in an experiment made especially to determine whether these acids were formed. The results of the second experiment except as above

* Residual gas.

stated are worthless, because the action of the discharge was not stopped until the ethylene was nearly all consumed and there was a large excess of oxygen present. The first experiment shows a ratio of the hydrogen and oxygen consumed in two hours to ethylene and oxygen of 5·6 to 12·4^{cc} or as 1 to 2·2, while in the last two the ratio is 1 to 3. The slower rate of combination of ethylene and oxygen in the first case is to be ascribed to the excess of oxygen present.

Acetylene and Oxygen.

The acetylene used in the following experiments was made from calcium carbide and kept over water. It proved to be nearly pure.

Hydrogen, 2 volumes. Oxygen, 1 "						Acetylene, 4·8 c. c. Oxygen, 15·7 c. c.				
Hours.	Temp.	Pressure.	Observed volume.	Reduced volume.	c. c. of gas combined.	c. c. of gas combined.	Reduced volume.	Observed volume.	Pressure.	Temp.
	17·4	121	139	20·8			20·5	137	121	17·4
1	15·2	101	135	17	**3·8**	**11**	9·5	129	59	15·2
							3·3	123	22	19
							Acetylene, 6·3 c. c.			
							Oxygen, 17·7 c. c.			
	10·5	100	136	17·2			24	140·5	135	10·5
1	14	74·5	133	12·4	**4·8**	**13·1**	10·9	130·5	66·5	14
							Acetylene, 8·2 c. c.			
							Oxygen, 18·4 c. c.			
	16·2	124·4	140	21·6			26·6	142	151	16
1	16·2	101·7	137	17·3	**4·3**	**13·9**	12·7	132	77·7	17
							Acetylene, 1 volume.			
							Oxygen, 2·5 volumes.			
	16·5	133	139	22·9			26·7	142	152	17
1	15·4	108·7	135·4	18·3	**4·6**	**14·6**	12·1	131	74	15·4
							0·7	123	4·7	18

In the first experiment the oxygen consumed was 15·7−3·3 =12·4 or 2·58 times the acetylene taken. In the last experiment the acetylene and oxygen were in the proportion required for complete oxidation of the former, and of the 26·7^{cc} of gases taken only 0·7^{cc} remained. The results show that acetylene in presence of sufficient oxygen is all converted into carbon dioxide and water by the glow discharge. 2·9, 2·7, 3·2, and 3·2 cubic centimeters respectively of acetylene and oxygen combined to 1 of hydrogen and oxygen. The lower results in the first two are evidently due to the excess of oxygen present in the mixtures.

Ethane and Oxygen.

The ethane used in the following experiment was made from ethyl iodide by the action of the zinc-copper couple in alcohol. The ethane and oxygen were measured in the eudiometers.

Hydrogen, 2 volumes. Oxygen, 1 "						Oxygen, 18·8 c. c. Ethane, 5 c. c.				
Hours.	Temp.	Pressure.	Observed volume.	Reduced volume.	c. c. of gas combined.	c. c. of gas combined.	Reduced volume.	Observed volume.	Pressure.	Temp.
	17	115	136	19·4			23·8	139	138	17
1	16	93	133	15·4	4	8·9	14·9	132	91	16
1	18	68	129	10·8	4·6	6·4	8·5	127	54	18
							7·5	126	48	18
					8·6	15·3				
							Oxygen, 16·6 c. c.			
							Ethane, 8 c. c.			
	17	113·5	136	19·1			24·6	139	143	17
½	17	103·5	135	17·3	1·8	2·6	22	137	129·5	17
1	15·6	79·5	132	13·1	4·2	7	15	132	91	15·6
1	16·6	55	130	8·9	4·2	6	9	127	57	16·6
							1·2	120	8	18
					10·2	15·6				
							Oxygen, 13·5 c. c.			
							Ethane, 8·5 c. c.			
	17·6	128	137	21·7			22	138	129	17·6
1	16·8	106	134	17·6	4·1	5·9	16·1	134	97	17
1	14 6	82	133	13·6	4	6·4	9·7	131	59	14·8
							4·7	123	31	17
					8·1	12·3				

One volume of ethane, C_2H_6, requires for complete combustion $3\frac{1}{2}$ volumes of oxygen. In the experiments, however, less than $2\frac{1}{2}$ were consumed. In the first, 5^{cc} of ethane and $11{\cdot}3^{cc}$ of oxygen ($18{\cdot}8^{cc}$ less $7{\cdot}5^{cc}$ residual oxygen) combined, and in the second 8^{cc} and $15{\cdot}4^{cc}$ ($16{\cdot}6-1{\cdot}2$). The oxidation was stopped in the third experiment when $9{\cdot}7^{cc}$ remained, and the oxygen in the mixed gases was found to be 5^{cc}, leaving $4{\cdot}7^{cc}$ per cent ethane. Deducting these numbers from the volumes of gases originally taken, we find that $3{\cdot}8^{cc}$ of ethane and $8{\cdot}5^{cc}$ of oxygen combined; 1·8, 1·5 and 1·5 cubic centimeters respectively of ethane and oxygen combined to 1 of hydrogen and oxygen. The rate of combination was most rapid in the first with an excess of oxygen present, and during the first hour was 2·2 times that of the hydrogen-oxygen mixture, while in the second hour it was much less owing to the large excess of oxygen present.

Molecular Changes.

The table below is based on the composition of the gases used and the ratio of the volumes combined to one volume of hydrogen and oxygen also combined under the influence of the glow discharge as before described. The ratio taken for carbonic oxide and oxygen is 1·13, the mean of all the results; for methane and oxygen 1·49, which appears to be the best result; for ethylene and oxygen 3, the result of the last two experiments with these gases; for acetylene and oxygen 3·2; and for ethane and oxygen 1·5. The volume ratios also represent the relative number of molecules combining, and for convenience these ratios are given in the table in whole numbers, and one volume of hydrogen and oxygen is assumed to contain 100 molecules.

Mixture of gases.	Molecules combined.	Molecules	oxidized.	Molecules of oxygen consumed.
Hydrogen and oxygen,	100	H_2	67	33
Carbonic oxide and oxygen,	113	CO	75	38
Methane " "	149	CH_4	49	100
Ethylene " "	300	C_2H_4	86	214
Acetylene " "	320	C_2H_2	91	229
Ethane " "	150	C_2H_6	50	100

The accuracy of the experimental work is by no means what is desirable, nevertheless it is evident that the same electric current caused the oxidation of a different number of molecules of the gases, the variation being as 1 to 2, while the oxygen consumed varied as 1 to 7 molecules. Moreover, the numbers representing the relative proportions of the molecules oxidized fall into two classes, viz: 67, 49, 50, and 75, 86, 91. The former are the numbers of saturated and the latter of unsaturated molecules oxidized. Ethylene and acetylene differ but little in deportment, although the latter is the more endothermic in character. Both combine more rapidly than carbonic oxide; methane and ethane combine at about the same rate but slower than hydrogen. If we calculate the amount of change in a mixture of hydrogen and oxygen on the basis that 3·6^{cc} combine in one hour, we find that 1 cubic millimeter of the mixture unites in a second. The space occupied by the glow discharge in the apparatus was about 30^{cc}, and the volume of gas at $\frac{1}{10}$th of an atmosphere equals 3000 cubic millimeters at standard pressure, that is, the molecules combining during one second were mixed with 3000 times as many molecules. This slow combustion did not raise the mean temperature of the gases, as the heat evolved was constantly lost by radiation. Whether the energy of oxidation induced by the electric glow

also causes chemical union, it is impossible to say. It seems, however, safe to assume that the heat energy plays little part in effecting chemical change for the reason that the heat of combustion increases in the series tabulated much faster than the number of molecules combining. We shall be sufficiently accurate in assuming the heats of combustion to be proportional to the oxygen consumed. For example, the oxidation of three molecules of acetylene gives seven times as much heat as one molecule of hydrogen. Further, if the energy resulting from the union caused by electricity of two molecules of hydrogen and one molecule of oxygen causes other molecules to combine, we should expect the energy of this phase of combination to cause further combination and rapid combustion or an explosion. If then the chemical changes in the mixed gases tested were not caused in part by heat, it remains to consider the nature of the change caused by electricity. Oxidation was not effected by ozone nor preceded by its formation, as the discharge was too feeble to produce sufficient ozone to account for the amount of oxidation. Moreover, hydrogen, carbonic oxide and methane resist ozone. The hydrocarbons also were but slightly decomposed by the glow discharge, as the following experiments show. 8·85^{cc} of methane, subjected to the discharge for an hour and a half, increased in volume 0·28^{cc} with formation of acetylene. The change may be expressed by the equation

$$2CH_4 = C_2H_2 + 3H_2.$$

That is, four volumes of methane yield eight volumes of gas. A similar test of 23·8^{cc} of ethane for an hour gave 0·4^{cc} increase in volume; only a small quantity of acetylene was formed. The reaction is

$$C_2H_6 = C_2H_2 + 2H_2.$$

That is, two volumes of ethane yield six volumes of gas. The decomposition of the hydrocarbons by the discharge is, therefore, too slight to account for the amount of change in the mixtures of oxygen. This fact and the non-formation of ozone indicate that the formation of water and carbon dioxide was not due to the union of ions, a view supported by the syntheses by Losanitsch and Jovitschitsch* of organic compounds. If chemical union in the cases discussed is not to be explained by the ion theory, we may infer that the glow discharge of electricity renders molecules chemically active and capable of interacting. We may thus consider the molecular changes involved in electrosynthesis to be analogous to those occurring in synthesis effected by heat or light where combination takes place at a temperature far below that at which the gaseous molecules dissociate.

* Loc. cit.

Art. IX.—*Monazite from Idaho;* by W. Lindgren.

The intermontane valley of "Idaho Basin" is situated thirty miles north-northeast of Boise City, Idaho, in the great granite area of the southern part of that state. Its placer mines have been of extraordinary richness and still contribute a considerable proportion of the gold production of Idaho. The gold-bearing gravels are of Pleistocene and Neocene age and, near Idaho City, there are also some Neocene lake beds containing only a slight amount of gold.

The sand of the gravels and lake beds of the Idaho basin is entirely derived from the granite and associated dike rocks. It consists of relatively angular and sharp-edged grains indicating its manner of formation by extremely rapid accumulation from the deeply disintegrated rocks.

In all parts of the basin a yellow or brownish yellow mineral forms a considerable quantity of the heavy substances remaining with the gold. The mineral has been shown to be monazite, this being the first time its occurrence has been noted from the western states. As well known, it occurs abundantly in the granite and gneissoid rocks and gold placer mines of the Southern Appalachians and in several of the northern Atlantic states, also in Brazil, the Ural Mountains and other places. There is no doubt it forms an original constituent of the granite of the Idaho Basin.

A sample washed from the lake beds near Idaho City consisted of the following minerals: ilmenite in sharp hexagonal crystals but no magnetite; zircon, also in extremely sharp crystals of a slightly brownish color; and abundant yellow or greenish yellow grains rarely showing crystallographic faces; the refraction and double refraction of this mineral were very high, the hardness not much over 5. The ilmenite was eliminated by the electro-magnet and the remaining powder, containing about 70 per cent of the yellow mineral, was analyzed by Dr. W. F. Hillebrand. The result showed it to be a phosphate of the cerium metals, the approximate amount of the oxides of the latter being 48 per cent; in these approximately 1·20 per cent of thoria was found. This result identifies the mineral with monazite, the only other similar mineral being xenotime, which is mainly a phosphate of yttrium with but little cerium.

Another sample furnished me by Mr. T. Smith of Placerville came from the alluvial gold washing in Wolf Creek near that town. Cleaned from quartz, etc., it appeared as a heavy dark sand consisting of a black iron ore (ilmenite), rounded crystals of red garnet, sharp crystals of zircon, and irregular

grains of a dark yellowish brown mineral with waxy lustre, sometimes showing crystallographic faces. It was found impossible to extract but a small part of the iron ore by the magnet; there was practically no magnetite present. This sand was examined by Dr. Hillebrand qualitatively with the result of finding phosphoric acid, cerium metals and thorium. The yellowish brown mineral is therefore in all probability monazite.

Although the monazite occurs in considerable quantity, it is doubtful whether the mineral can be profitably extracted except possibly as a by-product obtained from the gold washings.

Washington, D. C., May, 1897.

SCIENTIFIC INTELLIGENCE

I. Chemistry and Physics.

1. *On the Viscosity of Mixtures of Miscible Liquids.*—It has been pointed out by Thorpe and Rodger that the properties of a mixture of liquids are rarely identical with those which the mixture should possess on the assumption that the influence exercised by each constituent is proportional to its amount; possibly because the effect of solution in some cases is to break down the complex molecular aggregates of which certain liquids appear to be composed, and in other cases because it leads to the formation of aggregates of the same or of dissimilar molecules. Hence these authors have continued their experiments on the relation of the viscosity of a mixture of two chemically indifferent and miscible liquids to the viscosity of its constituents; with a view to determine whether the viscosity is related to the number of molecules per unit volume or per unit surface. The pairs of liquids used were carbon tetrachloride and benzene, methyl iodide and carbon disulphide, and ether and chloroform. The results obtained afford additional evidence of the fact that the viscosity of a mixture of miscible and chemically indifferent liquids is rarely if ever, under all conditions, a linear function of the composition. A liquid in a mixture rarely preserves the particular viscosity it possesses when unmixed. As a rule the viscosity of the mixture appears to be uniformly lower than the mixture rule would indicate, though no simple rule can yet be traced between the viscosity of a mixture and that of its constituents.—*J. Chem. Soc.*, lxxi, 360, April, 1897. G. F. B.

2. *On the Specific Heats of the Gaseous Elements.*—The known facts with respect to the specific heats of the gaseous elements have been summarized by Berthelot. He points out four distinct cases: (1) where the ratio of the two specific heats is 1·66 and the molecules are generally believed to be monatomic; (2) where the ratio is 1·41 and the molecules behave as if they were diatomic and show no sign of dissociation into monatomic molecules, although at high temperatures there are indications that such dissociation is beginning to take place; (3) where the ratio is 1·30 (chlorine, bromine and iodine) and the diatomic molecules dissociate more or less completely at high temperatures. The ratio in these cases indicates that a considerable amount of internal work is done when the temperature of the gas is raised between ordinary limits; (4) where the ratio is 1·175 and the molecule is tetratomic, but becomes diatomic at high temperatures. The specific heats at constant volume in the four cases are 3·0, 4·8, 6·6 and 11·4, and the ratios of the three chief numbers are not far removed from 1 : 2 : 4. There is therefore some ground for supposing that the specific heats of elementary gases at constant

volume are proportional to the number of atoms in their molecules. —*C. R.*, cxxiv, 119, January, 1897. G. F. B.

3. *On the Synthetic Action of the Dark Electric Discharge.*—An extended series of experiments has been made by LOSANITSCH and JOVITSCHITSCH upon the action of the dark electric discharge in producing chemical synthesis. The apparatus used was the ozonizer of Berthelot, which the authors propose to call an "electriser." Connected with it was a lateral tube dipping in water or mercury, by means of which the change in volume during the reaction could be noted. A current of from 3 to 5 amperes and an electromotive force of 70 volts was used to excite a large induction coil. When carbon monoxide and water vapor was contained in the electriser, the manometer showed contraction at once on passing the spark, the water column rising 400^{mm} in two hours. The tube contained a strongly acid liquid which was proved to be formic acid by its reducing power on ammonio-silver nitrate. Carbon dioxide and water gave formic acid and oxygen when subjected to the dark discharge in the same tube, $CO_2 + H_2O = HCOOH + O$; the oxygen subsequently acting on the water to produce H_2O_2. With hydrogen and carbon monoxide, the pressure diminished to half an atmosphere in three hours, some drops of a thick liquid being formed; there being produced at first formic aldehyde probably, $CO + H_2 = COH_2$, and this polymerizing to glycolaldehyde. Carbon dioxide with hydrogen gave formic acid, and with marsh gas gave at first acetic aldehyde and subsequently its polymer aldol. With hydrogen sulphide, carbon monoxide gave at first formic aldehyde with separation of sulphur; thioformic aldehyde resulting subsequently from the action of this upon the hydrogen sulphide. With hydrogen chloride, carbon monoxide gave probably formyl chloride. With ammonia it yielded formamide with a trace of hydrogen cyanide. Hydrogen sulphide and hydrogen gave carbon monosulphide and hydrogen sulphide; while with carbon monoxide it gave carbon oxysulphide and monosulphide. Nitrogen and water, as already proved by Berthelot, yielded ammonium nitrite. The unsaturated hydrocarbons under these conditions polymerized themselves very readily.—*Ber. Berl. Chem. Ges.*, xxx, 135, January, 1897.

G. F. B.

4. *On Structural Isomerism in Inorganic Compounds.*—By the action of hydroxylamine sulphate upon barium hypophosphite, SABANÉEFF has succeeded in obtaining hydroxylamine hypophosphite, $NH_3O \cdot H_3PO_2$. Since the salt when in solution oxidizes readily in the air, it is necessary to conduct the operation in an atmosphere of carbon dioxide. The solution thus obtained shows all the reactions of hydroxylamine and of hypophosphorous acid and contains not a trace of phosphorous acid, which however readily appears on the access of air. It is decomposed when evaporated on the water-bath, but on spontaneous evaporation it yields needle-shaped crystals, containing by analysis 30·95 per cent phosphorus. These crystals are hygroscopic, dissolve readily

in water, effloresce at 60° to 70°, fuse at 92° to an opaque mass, sometimes exploding. Cryoscopic examination established the molecular mass corresponding to the above formula. The interest attaching to this compound is due to the fact that it is isomeric (metameric) with hydrogen ammonium phosphite, a salt formed by Amat in 1887 by neutralizing phosphorous acid with ammonia and which has the formula $NH_3 . H_3PO_3$. On evaporating its solution on the water bath, this salt separates in crystals belonging to the monoclinic system. These crystals may be heated to 100° without change and fuse with partial decomposition at 123°. Harden has noted the fact that this is not the first instance of this sort, since Röhrig's sodium-potassium sulphites and Schwicker's thiosulphates are also structurally isomeric.—*Ber. Berl. Chem. Ges.*, xxx, 285, February, 1897. G. F. B.

5. *The Phase Rule;* by WILDER D. BANCROFT. 8vo, pp. viii, 255. Ithaca, N. Y., 1897. (The Journal of Physical Chemistry.) 83.—Classifying the work done in Physical Chemistry under the heads of Qualitative Equilibrium, Quantitative Equilibrium, Thermochemistry and Mathematical Theory, the author has sought in the present volume to present the subject of qualitative equilibrium from the point of view of the Phase Rule and of the Theorem of Le Chatelier, without the use of mathematics. He defines a phase as a mass chemically and physically homogeneous, i. e., a mass of uniform concentration; and the components of a phase as the substances of independently variable concentration contained in the phase. Now according to the Phase Rule of Willard Gibbs, the state of a phase is completely determined if the pressure and temperature, together with the chemical potentials of its components, be known. Hence the phase may be described by an equation connecting these quantities; while for every other phase in equilibrium with this, there will be another equation containing the same variables. The number of such equations therefore will be the same as the number of phases; while the number of independent variables will equal the number of components plus the temperature and pressure. If n represent the number of components, the number of variables will be $n+2$; and in a system of $n+2$ phases there will be as many theoretical equations as there are variables. In other words, each of the variables has one value and one only for a given set of $n+2$ phases. A given combination of $n+2$ phases can exist at one temperature and one pressure only, the composition of the phases being also definitely determined. Such a system is called a non-variant system, the temperature and pressure at which alone it can exist being known as the inversion temperature and pressure. If the number of phases be $n+1$ however, the system is no longer completely defined, has one degree of freedom and is called a monovariant system. In this system for a given combination of phases there is for each temperature one pressure and one set of concentrations for which the system is in equilibrium; for each pressure, one temperature and one set of concentrations;

and for each set of concentrations, one temperature and one pressure. If however one of the variables be arbitrarily fixed the system is again completely defined. If the number of phases be n, the system is called a divariant system, there being in it two variables which can be arbitrarily fixed before the system is completely defined. In studying the possible variations in equilibrium caused by changing the different variables and the number of phases, the author makes use of the Theorem of Le Chatelier, which says: "Any change in the factors of equilibrium from outside is followed by a reverse change within the system." He then passes to the discussion of nonvariant, monovariant and divariant systems, starting with a single component and increasing to four. Taking, as the most familiar example of a nonvariant system made up of one component, the equilibrium between solid, liquid and vapor, as observed for example in the system composed of ice, water and water vapor, the author points out that according to the Phase Rule a system of this type can be in equilibrium at only one temperature and one pressure, this temperature for water being $+0{\cdot}0066^\circ$ and the pressure $4{\cdot}6^{mm}$ of mercury; these being the inversion temperature and pressure. Applying the theorem of Le Chatelier to the changes in the relative masses of a nonvariant system, we see that if the system is kept at the inversion temperature and the external pressure is continuously increased, a system will result occupying a lesser volume, the vapor condensing until the vapor phase has disappeared and the monovariant system solid and liquid, is left. So changes may be effected by varying the temperature, the pressure being kept constant, the addition or subtraction of heat taking place while the system is kept at constant pressure or at constant volume. The three monovariant resulting systems may exist over a series of temperatures and a series of pressures bounded only by the appearance of new phases. Representing these results in the case of water graphically, the author passes to consider sulphur and phosphorus similarly. In the fourth chapter, he takes up the question of two components, first as anhydrous salt and water, as hydrated salts and as volatile solutes, and then as two liquid phases, as consolute liquids and as solid solutions. Systems of three components are next treated under the heads of two salts and water, pressure curves, solid solutions, isotherms, fractional evaporation, two volatile components, components and constituents and two liquid phases. A single chapter on the general theory of systems of four components completes the book. It appears to us that the task which Dr. Bancroft has set before himself has been admirably done, whether we consider the plan of his work or the manner of its execution. His volume is an admirable presentation of a somewhat abstruse subject which will be most useful to both the chemist and the physicist. G. F. B.

6. *Vorlesungen über Bildung und Spaltung von Doppelsalzen*; von J. H. Van't Hoff, Professor zu der Universität Berlin. Deutsch bearbeitet von Dr. Theodor Paul. 8vo, pp. iv, 95. Mit 54

Figuren im Text. Leipzig, 1897. (Wilhelm Engelman.) 3 marks.—The brochure before us contains the substance of the author's lectures given in Amsterdam in 1894–5 and in Berlin in 1896, upon the formation and decomposition of double salts, being a résumé of the investigations made by the author and his students upon this subject. In putting it into print the lecture form has been changed and the matter has been arranged under three subdivisions. In the first, which is theoretical and general, the action of a sparingly soluble double salt formed by the union of two binary salts, is considered, with reference to the author's theory of dilute solutions and of electrolytic dissociation. In the second, the experimental methods made use of in the investigations are described, these methods being original and most suggestive. In the third, which is special, the behavior of certain salts, such as potassium-cupric chloride, $CuCl_2 . (KCl)_2 . (H_2O)_2$, schönite, $MgK_2(SO_4)_2 . (H_2O)_6$, the racemates of ammonium and sodium and of potassium and sodium and the dextro- and lævorotatory Rochelle salts is given at length and shown to be in accord with theory. It is evident therefore that a distinct progress has been made by Professor Van't Hoff over the results given in his "Chemical Dynamics." In the latter book the question of temperature was the one mainly considered, while in the present work all the other conditions upon which the existence of double salts depends are studied minutely. The book is a most valuable addition to the literature of physical chemistry.

G. F. B.

7. *The Limits of Audition;* by Lord Rayleigh. (Abstract.) —In order to be audible, sounds must be restricted to a certain range of pitch. Thus a sound from a hydrogen flame vibrating in a large resonator was inaudible, as being too low in pitch. On the other side, a bird-call, giving about 20,000 vibrations per second, was inaudible, although a sensitive flame readily gave evidence of the vibrations and permitted the wave-length to be measured. Near the limit of hearing the ear is very rapidly fatigued; a sound, in the first instance loud enough to be disagreeable, disappearing after a few seconds. A momentary intermission, due, for example, to a rapid passage of the hand past the ear, again allows the sound to be heard.

The magnitude of vibration necessary for audition at a favorable pitch is an important subject for investigation. The earliest estimate is that of Boltzmann. An easy road to a superior limit is to find the amount of energy required to blow a whistle and the distance to which the sound can be heard (e.g. one-half a mile). Experiments upon this plan gave for the amplitude 8×10^{-8} cm., a distance which would need to be multiplied 100 times in order to make it visible in any possible microscope. Better results may be obtained by using a vibrating fork as a source of sound. The energy resident in the fork at any time may be deduced from the amplitude as observed under a microscope. From this the rate at which energy is emitted follows when we know

the rate at which the vibrations of the fork die down (say to one-half). In this way the distance of audibility may be reduced to 30 metres, and the results are less liable to be disturbed by atmospheric irregularities. If s be the proportional condensation in the waves which are just capable of exciting audition, the results may be expressed :

c'	frequency = 256	$s = 6{\cdot}0 \times 10^{-9}$
g'	" = 384	$s = 4{\cdot}6 \times 10^{-9}$
c''	" = 512	$s = 4{\cdot}6 \times 10^{-9}$

showing that the ear is capable of recognizing vibrations which involve far less changes of pressure than the total pressure outstanding in our highest vacua.

In such experiments the whole energy emitted is very small, and contrasts strangely with the 60 horse-power thrown into the fog-signals of the Trinity House. If we calculate according to the law of inverse squares how far a sound absorbing 60 horse-power should be audible, the answer is 2700 kilometers! The conclusion plainly follows that there is some important source of loss beyond the mere diffusion over a larger surface. Many years ago Sir George Stokes calculated the effect of radiation upon the propagation of sound. His conclusion may be thus stated. The amplitude of sound propagated in plane waves would fall to half its value in six times the interval of time occupied by a mass of air heated above its surroundings in cooling through half the excess of temperature. There appear to be no data by which the latter interval can be fixed with any approach to precision; but if we take it at one minute, the conclusion is that sound would be propagated for six minutes, or travel over about seventy miles, without very serious loss from this cause.

The real reason for the falling off at great distances is doubtless to be found principally in atmospheric refraction due to variation of temperature, and of wind, with height. In a normal state of things the air is cooler overhead, sound is propagated more slowly, and a wave is tilted up so as to pass over the head of an observer at a distance. [Illustrated by a model.] The theory of these effects has been given by Stokes and Reynolds, and their application to the explanation of the vagaries of fog signals by Henry. Progress would be promoted by a better knowledge of what is passing in the atmosphere over our heads.

The lecture concluded with an account of the observations of Preyer upon the delicacy of pitch perception, and of the results of Kohlrausch upon the estimation of pitch when the total number of vibrations is small. In illustration of the latter subject an experiment (after Lodge) was shown, in which the sound was due to the oscillating discharge of a Leyden battery through coils of insulated wire. Observation of the spark proved that the total number of (aerial) vibrations was four or five. The effect upon the pitch of moving one of the coils so as to vary the self-induction was very apparent.—*Royal Institution of Great Britain*, April 9, 1897.

8. *Polarization Capacity.*--C. M. GORDON enters into a historical discussion of this subject, cites the various investigators who have worked upon it and gives his own results, carried out by Nernst's method under the direction of the latter. This method consists in comparing the polarization capacity with a known capacity in the Wheatstone bridge. It was found that for small strength of current the polarization is a reversible process and the contrary electromotive force is accurately given by Kohlrausch's equation $\epsilon=\frac{1}{cf\int Jdt}$ in which c is capacity, f a constant, J equals current strength and t equals time. The capacity of quicksilver electrodes depends mainly upon the quantity of dissolved mercury ions. The capacity of platinum electrodes depends not only upon the occluded hydrogen or oxygen but also upon the concentration of these electrolytes. The results of Gordon do not agree with those of Wien, who found a close dependence of polarization capacity upon the period of the alternating current employed to excite the Wheatstone-bridge combination. Gordon, on the contrary, finds that Kohlrausch's law holds very exactly. The capacity of plates of polished platinum, at a distance of 2^{mm}, and having a surface $0{\cdot}65^{cm^2}$, was about 50 microfarads.— *Wied. Ann.*, No. 5, 1897, pp. 1–29. J. T.

9. *Oscillatory Currents arising in Charging a Condenser.*--SEILER gives a short analytical discussion of the conditions which arise in charging a condenser, and shows that the same equation holds for the charging oscillations as for the discharging oscillations, namely, $T=2\pi\sqrt{LC}$, in which T represents time, L self-induction and C capacity. The author uses this law for the determination of the self-induction of suitable circuits. He employed a Helmholtz pendulum and used two contacts which broke the charging circuit at definite intervals. It was found that only pure sine oscillations resulted when the circuit contained no small spark gaps.— *Wied. Ann.*, No. 5, 1897, pp. 30–54.

J. T.

10. *Cathode Rays.*--In a late discourse delivered at the Royal Institution, Prof. J. J. Thomson described experiments which lead him to believe that the cathode ray phenomena are due to projected electrified particles. Atoms are aggregations of small particles which he terms corpuscles. At the cathode some of the molecules of the gas are split up into these corpuscles, whch are then charged negatively and moving with a high velocity are able to pass between the interstices of molecules. The corpuscles are smaller than the atoms of hydrogen. (Lond. Electr., May 21.) Somewhat in line with Thomson's hypothesis is an observation on Dr. Zeeman's discovery of the broadening of spectral lines in a magnetic field, by Dr. Kalischer. (Elektrotecknische Zeitschrift, April 15, 1897.) This author points out that there is a recent tendency to return to a "material theory," in which electrical and magnetic phenomena depend not only upon the movement of the ether but also on the material atoms which are sup-

posed to be able to carry electrical charges as in the case of electrolytes. Lorentz explains electrical phenomena by the grouping of corpuscles, and supposes the undulations of light to be the vibration of the ions. It is interesting that he predicted a phenomenon similar to that discovered by Dr. Zeeman. J. T.

11. *Application of the Röntgen Rays to Surgery.*—The recent numbers of French Scientific Journals contain many articles on the application of the X-rays to surgery. M. Ollier describes his researches upon the osseous regeneration in man after surgical operations. Observations hitherto on this subject have been very difficult, and one had to study the cases after death. The X-rays now permit an exact study of the form of the osseous development, and in certain cases render unnecessary the amputation of diseased limbs, since the diseased portions can be now accurately located and removed.—*Comptes Rendus*, No. 20, May 17, 1897. J. T.

12. *Transparency of Ebonite.*—M. PERRIGOT, in a note presented to the Academy by M. Mascart, states that plates of ebonite $0{\cdot}5^{mm}$ thick are transparent to red light; light passing through plates 2^{mm} thick also affects orthochromatic plates.—*Comptes Rendus*, No 20, May 17, 1897. J. T.

13. *The Theory of Electricity and Magnetism, being Lectures on Mathematical Physics;* by ARTHUR GORDON WEBSTER; pp. 576, 1897. (The Macmillan Company.)—This extensive text book on the mathematical theory of electricity is designed especially for the use of advanced students in our American colleges, and is intended to embody the improvements and additions which have been made in this domain of science since the time of Maxwell's famous work. These additions, derived from the labors of Helmholtz, Hertz, Heaviside and others, are carefully and instructively indicated. An effort to employ a consistent and convenient notation throughout seems to have been pursued with success, for which the author will surely deserve the thanks of his readers.

Professor Webster's experience has taught him that few students who have received only undergraduate instruction in mathematics are sufficiently advanced to enter at once upon the subject of mathematical physics. Hence, to quote from his preface, "I have therefore considered it expedient to prefix a mathematical introduction giving a short treatment of the important subjects of Definite Integrals and of the Theory of Functions of a Complex Variable, indispensable to a study of the Potential Function. For the same reason, I have included a treatment of the fundamental principles of Mechanics *ab initio*, including the deduction of the Principle of Energy, Hamilton's Principle, and Lagrange's Equations of Motion. . . . . In this manner it has come about that the book is nearly half finished before the word *Electricity* is mentioned. This may be objectionable to some persons, but I consider it of great importance that the student should be well supplied with tools and practiced in their use before he is called upon to use them on a new and unfamiliar subject. . . . . Thus

these introductory chapters may serve as a sort of general introduction to Mathematical Physics."

The author's style is very concise but lucid and interesting. A notable feature of his book is the admirable character of the diagrams both in clearness and sightliness. Professor Webster is to be congratulated upon having produced an excellent book, which is certain to be used and valued. C. S. H.

14. *Light and Sound;* by E. L. NICHOLS and W. S. FRANKLIN. pp. 201. New York, 1897. (The Macmillan Company.)—The present volume is the third and concluding part of the authors' *Elements of Physics.* The work as a whole, though intended as a college text-book, is rather a digest than a treatise upon this subject, and as such will doubtless find its widest circle of readers among students preparing for examination, or seeking for the theory of the apparatus they must use in the laboratory.

The character of the last part is more freely descriptive than its predecessors, the phenomena and the laws governing them being very properly given more prominence than the formulas which aid in their statement. A commendable feature of the book is the introduction of Huygen's Principle at the beginning, and a development in general of the subjects of reflection and refraction as modifications of a wave-surface at the boundary of different media. There are, however, dreary lapses into "rays" and Optic Geometry in the discussion of mirrors and lenses where the relation between the luminous point and its image is stated, and the reader told that by certain substitutions the given expression may be reduced to an identity. As far as possible the objective wave phenomena of sound and light are treated side by side. Diagrams of a simple character are lavishly distributed throughout the book, and average about one to a page.

Among minor criticisms it may be suggested that fig. 485 would be made much clearer by perversion and rotation through a right angle, and that saturation should be admitted to co-ordinate rank with the other characteristics of a color sensation on p. 101. It is questionable whether anything is gained by such liberties with well-recognized scientific usage as radius of *curvation* for radius of curvature, p. 32; *allotropic* for anisotropic, p. 128, unless perchance this is a misspelling of æolotropic; *resonant* dispersion for anomalous dispersion, p. 145; luminescence for simple fluorescence, p. 146.

The chapter on Photometry and the one on Musical Intervals and Scales, which brings the work to a close, though brief, are especially good. F. E. B.

II. Geology and Mineralogy.

1. *Examination of Deposits obtained from borings in the Nile Delta.*—Prof. John W. Judd has given to the Royal Society a report on a series of specimens of the deposits of the Nile Delta, obtained by boring operations, a continuation of similar work the results of which were published in 1885. The later borings here described were made at Zagazig, and were carried down 100 feet with a 5-inch pipe, and nearly 100 feet farther with a 4-inch pipe. The work was then discontinued, but renewed again a year later, and by vigorous efforts carried to a depth of 339½ feet with a 3-inch pipe, and from this point a rod was pushed down 5 feet 6 inches farther, so that the exploration attained a total depth from the surface of 345 feet, or 319 feet below the sea level, *without reaching solid rock.*

It is stated that from the surface to a depth of 115 feet the strata passed through in the Zagazig boring closely resembled those already reported upon as occurring in the earlier borings, and consisted of alternations of desert-sand and Nile-mud. The alluvial mud, which prevails from the surface to a depth of 20 feet, contains numerous small tubular and knot-like bodies, doubtless formed by the deposition of calcium carbonate on the rootlets of plants. These bodies become fewer at greater depth and are absent in the clay from depths between 75 and 92 feet. At this level an indurated alluvial mud was found in irregular masses of concretionary argillaceous limestone.

A sudden change in the deposits was found at a depth of 116 feet; here beds composed of a mass of coarse sand and shingle were met with and continued to a depth of 151 feet. At the latter depth a band of yellow clay was passed through, two feet in thickness, and under it sand and shingle beds prevailed till the lowest depth reached, 345 feet. Specially coarse shingle beds were found at the following depths: 121, 160, 175, 190, 208, 250, 265, and 270 feet. In some of these shingle beds the fragments, which were usually well rounded—often, indeed, perfect pebbles—were very coarse, the fragments being of all sizes up to that of a hen's egg.

The general results obtained are similar to those from a boring made at Rosetta in the summer of 1885 and carried to a depth of 153 feet. The sudden change from the blown sand and alluvial mud of the Nile delta to masses of shingle and sand noted at a depth of 115 feet at Zagazig was met with at a depth of 143 feet at Rosetta, showing that the surface of the old gravel deposits is very uneven.

A careful search was made for fossils, especially in the clays, in order, if possible, to fix the geological age of the deposits underlying those of the delta; but this attempt was unsuccessful. The pebbles consisted largely of quartz and chalcedony, and sandstones, all of which, it is suggested by Dr. K. von Zittel of Munich, may have been derived from the Gebel Achmar Sand-

stone. The absence of limestone and pebbles was striking, the softer rocks apparently having been entirely worn away. In the shingle beds pebbles were also found of igneous rocks, which, it is suggested, may have been derived from the side valleys of the Arabian Desert. A number of the pebbles of flint and flinty limestone contained foraminifera and, apparently, sponge-spicules. These fossils are regarded by Prof. Rupert Jones as proving that the fragments containing them were derived from the Eocene (Nummulitic) limestones of Egypt, thus fully confirming the conclusions of Dr. von Zittel.

Of the general sources from which these pebbles were derived Dr. von Zittel writes as follows:—"On the whole it appears to me conceivable that these gravels under the delta originated at a time when the Nile had already formed its present valley, but not to so great a depth as at present. The majority of the rolled rock-fragments would seem not to have been derived from points extremely distant from those in which they are at present found."

Prof. Judd adds: "In considering the nature and sources of the pebbles found in the boring at Zagazig, it may be well to point out that the spot where the boring was carried out is directly opposite to the Great Wady (W. Tumilat), which opens on the delta from the east, and that much of the materials composing the gravels may have been brought down by this tributary rather than by the main stream of the Nile itself. Hence we may not have in this particular section so good an average sample of the contents of the Sub-delta formation as would be obtained at other localities.

"There can scarcely be the smallest doubt that in this Sub-delta formation we have a series of deposits, which were formed under totally different conditions from those which prevail in North Eastern Africa at the present time. The land must have been at an elevation at least from 100 to 300 feet higher than at present, and the Lower Nile, instead of forming an alluvial flat, as at present, must have deposited coarse sands and gravels. It is upon the very uneven surface of this Sub-delta deposit that the alluvial mud and sands of the delta have been deposited, as the surface gradually subsided below the level of the Mediterranean. The interesting problem of the geological age of this Sub-delta deposit remains to be solved, but it may he hoped that the explorations now being carried on by the Geological Survey of Egypt, under Captain H. G. Lyons, R.E., F.G.S., may furnish new and important evidence bearing on this important question. It is to be regretted that the borings carried out by the Royal Society have not set at rest the doubts which have long existed as to the depth at which the solid rock-floor lies below the surface of the delta. But while this has not yet been accomplished, it is satisfactory to have been able to show that the supposed insignificant thickness of the alluvial deposits is altogether a mistake, while the existence of an underlying formation, laid down under conditions totally different to those which prevail at present, has been demonstrated."

2. *Underground Temperatures at Great Depths.*—W. HALLOCK, in a paper published in "The School of Mines Quarterly" (vol. xviii), gives some interesting observations on subterranean temperatures at Wheeling, W. Va., and Pittsburgh, Pa. The original temperatures obtained at different depths of the Wheeling well were given in a paper by Dr. Hallock in this Journal (vol. xviii, 234). These observations were finished in 1891; an oak plug was then driven into the top of the casing and the hole thus protected. In 1893 the hole was opened and it was found full of water to within 40 feet of the top, the water having probably entered at the lower end of the inner casing, 1570 feet below the surface. Careful observations of the temperature were made in 1893, showing results differing not more than 0°·2 F. from those obtained in 1891, thus indicating that no appreciable circulation even of water goes on in a hole of five inches diameter.

Another well now being bored at Pittsburgh, by the Forest Oil Company, had attained, in February, 1897, a depth of 5,386 feet, and it is expected that the work will be continued until a considerably greater depth has been reached. This well is dry and has an inlet of gas at a depth of 2,285 feet. Observations at a depth of 2,350 feet gave a temperature of 78°, or about the same as that of the Wheeling well. At a depth of 5,000 feet a temperature of 120·9° was obtained, which indicates a temperature of 127° at the bottom. A fuller record of temperatures is to be furnished at a later date.

3. *The Depth of Peat in the Dismal Swamp;* by G. R. WIELAND. (Communicated.)—During a recent visit to the Dismal Swamp region and Lake Drummond I found that a section now to be obtained at the excavation just completed for a lock on the "Feeder Canal" about one-half mile east of Lake Drummond and at the very center of the swamp, gives open testimony to the thickness of the peat accumulation and the origin of the lake.

These are about ten feet of peat containing many large roots, or even tree trunks; this followed by a layer of very clear peat some eight feet in thickness resting on a clear quicksand containing marine shells. Oyster and clam shells are quite numerous, and very likely they could also be obtained by dredging from the sandy bottom of the lake, which has a depth of about twenty feet. The clear peat followed by rooty peat indicates a peat invasion of the swamp area followed by an advance of forest growth. That the accumulation of vegetable matter is only eighteen feet in thickness is in full accord with the quick succession of geological changes the region has undergone, as pointed out by Shaler.—*Ann. Rep. U. S. Geol. Sur., Pt. I., 1888–9.*

4. *Currituck Sound, Virginia and North Carolina—A Region of Environmental Change;* by G. R. WEILAND. (Communicated.)—One of the most important geological changes which has taken place along the Atlantic coast in recent time was the closing up of the Currituck Inlet, North Carolina, by drifting sands in 1828. Previous to that year this inlet formed such a passage from the

ocean through a narrow outer beach into the waters of Currituck Sound as is formed by either the new or Ocracock Inlet to Pamlico Sound now. With the closing of the Currituck Inlet there was the conversion of upwards of one hundred square miles of shallow salt to brackish water area to fresh water; and it is within the memory of men now living that the resultant changes were immediate and striking.

Previously the sound had been a valuable oyster bed. Within a few years the oysters had all died out and their shells may now be seen in long rows where they have been thrown out in dredging for a boatway in the Coinjock Bay, a southwestern extension of the Sound. Further, there were such changes in vegetation as brought countless thousands of ducks of species that had been only occasional before. The salt water fishes were driven out and fresh water fishes took their place.

5. *Papers on Dæmonelix.*—The number of the University Studies, published by the University of Nebraska, for January, 1897, vol. ii, No. 2, contains an important paper by E. H. Barbour, on the history of the discovery of Dæmonelix with notes on the results of further study in regard to it. This paper is accompanied by seventeen excellent plates showing the forms in great variety, the method of occurrence, and the microscopic structure. The author feels entirely convinced that the forms have organic origin, and are not to be explained as the burrows of a rodent. A second paper by T. H. Marsland, in the same number, gives the result of chemical examination of the composition of the siliceous tubes. The analysis of different samples varies somewhat widely, but the material is shown to consist to a large extent of free hydrous-silicic acid with silicates of iron, aluminum, manganese, calcium, and magnesium.

6. *Papers and Notes on the Genesis and Matrix of the Diamond;* by H. Carvill Lewis. 8°, 72 pp., 3 pls. London, 1897. (Longmans, Green & Co.)—This volume consists of two hitherto unpublished papers by the late Prof. Carvill Lewis; also a third compiled and edited from manuscript notes left by him by Prof. T. G. Bonney. The first two papers were read before the British Association.

The work is chiefly petrographic in its nature and in a variety of ways it is proved that the rock accompanying the diamonds in South Africa is of igneous origin, a member of the peridotite group, and that the diamonds have been formed by the contact metamorphism of included fragments of carbonaceous shales. Similar rocks from the United States are also described. The editor differs from the author as to the precise method of occurrence of the igneous rock, while agreeing with him in other particulars. The whole forms an important and valuable addition to our knowledge respecting rocks of this class and the origin of the diamond, and students of this branch of science are much indebted to both Mrs. Lewis and the editor for giving these papers to the public in such attractive form. L. V. P.

7. *Transactions of the Geological Society of South Africa.* Edited by the Secretary. Johannesburg, 1897. Vol. ii, Nos. 1–11, pp. 1–164, has been issued under the date of March 1, 1897. It contains a series of papers on the geologic formations of South Africa.

8. *The Geological Survey of Canada: Report of the Section on Chemistry and Mineralogy.* By. G. CHRISTIAN HOFFMAN, Ottawa, 1897.—This report contains, in addition to the results of numerous technical analyses, assays of ores of different character, etc., also notes on some rare mineral species which have been recently identified in Canada. An analysis is given of the massive *scheelite* from the Malaga gold mining district, Queens Co., Nova Scotia. *Tetradymite* has been found in foliated masses near Liddel Creek, in the West Kootenay district of British Columbia. Its corrected specific gravity was found to be 7·184 and the analysis by R. A. A. Johnston, after deducting some 3½% of quartz, gave the following results:

Te	S	Se	Bi	Pb	Ag	Tl
37·29	4·45	*tr.*	53·69	3·63	0·94	*tr.* = 100.

Altaite has been found with various copper minerals at the Lake View Claim, on Long Lake, Yale district, British Columbia. Its corrected specific gravity was found to be 8·081 and the analysis by R. A. A. Johnston gave the following results:

Te	Pb	Ag	S
43·01	54·04	2·27	0·68=100.

The same locality has also yielded hessite, while the allied species petzite has been found at the Calumet Claim, Kruger Mt., in the Yale district, British Columbia. *Stromeyerite* has been found at the Silver King mine, Toad Mt., in West Kootenay district, British Columbia. It occurs in granular form of specific gravity 6·277, and the mean of two analyses by Johnston gave the following results:

S	Ag	Cu	Fe
15·74	52·27	31·60	0·17=99·78.

The cobaltiferous variety of arsenopyrites called *danaite* has been obtained from Monte Cristo Mt., Trail Creek, West Kootenay, British Columbia, where it occurs in indistinct crystalline form distributed through the gang of crystalline calcite with a little intermixed quartz. A corrected analysis by Johnston gave the following results:

As	S	Fe	Co
47·60	19·70	29·65	3·05=100.

III. Botany.

1. *Professor van Tieghem's new System of Classification of Phænogamia.*—Those who have watched the recent tendencies in systematic Phænogamic botany will not be wholly surprised to receive a proposition to change the values of some of the characters depending on the structure of the seed, and to base thereon an attempt at the partial reclassification of flowering plants.

In Comptes Rendus, May 3, 1897, Professor van Tieghem of Paris offers for consideration a new system for the classification of Phanerogams, based on the ovule and the seed. For this system, previous papers in the same periodical, beginning with that for March 22 of the current year, and in the Bulletin of the Botanical Society of France, for a much longer time, have been preparing the way.

Reserving for a later notice a more detailed account of the principal features of this new system, it is sufficient, at present, to call attention to its revolutionary character. It removes many old landmarks and obliterates many dividing lines, brings about the partial re-arrangement of established genera, placing them in new families, and, in general, initiates a new order of things. One's first impulse is to minimize the significance of the new characters, and to reject the basis proposed. But on careful investigation of the grounds of the new system, especially when such investigation keeps in mind the work by J. G. Agardh, in 1858, on somewhat similar lines, it becomes clear that the new system is likely to challenge wide attention, and that its claims are sure to be heard.

In the first paper of the recent series, the author, after briefly stating modern views relative to the gametes involved in fertilization, calls attention to the sequence of phenomena which, following fertilization, culminate in the production of the "fruit."

Fruits, at their maturity, are of two sorts, one of which has hitherto, in some of its phases, escaped notice. Most frequently the fruit bears (on its outer surface in the case of *Cycads* and *Conifers*, on the inner surface of a closed cavity in the case of all other Phanerogams) one or more distinct bodies which can be easily detached, or which may even become detached spontaneously, when the fruit is ripe. Each of these bodies, formed of an embryo, accompanied or not by albumen, and enveloped by its proper integuments, constitutes what everybody calls a "seed." On its germination, the seed produces a new plant. Most phanerogams have a fruit provided with seeds, *un fruit séminé*. Sometimes, on the contrary, the fruit neither bears nor contains any such free body which can be separated at maturity. In these latter cases, the whole is in one piece which must be planted as a whole in order to obtain by germination the new plant. Such a fruit is devoid of seeds, *un fruit inséminé*. On this difference, the author divides all Phanerogams into two classes, termed respectively *Séminées* and *Inséminées*. The first of these two primary groups is evidently more highly developed than the second. Each of these groups is next divided by the author on the basis of differences in the ovule.

The *Séminées* are first considered. The carpel is often cut along its edge into one or more folioles, more or less distinctly petioled. Each of these folioles produces at some part of the median line of its limb, a conical outgrowth or emergence, which is soon covered by an annular elevation of its own epidermis and, subsequently, is more deeply covered by the infolding of the limb itself. The terminal exodermic cell of this emergence produces directly or indirectly the mother-cell of the endosperm. This highly differentiated body, composed of four distinct parts, is an ovule. The petiole of the foliole is its funiculus; the emergence is the nucellus; its first envelope, comparable to the indusium of ferns, the internal integument; its second envelope is the external integument: each of these envelopes has an orifice, the endostome for the first, and the exostome for the second, together constituting the micropyle. Such an ovule is *nucellé* and *bitegminé*. But often, the nucellus has only one integument, namely the outer (the inner one being wholly wanting). Such an ovule is *nucellé* and *unitegminé*.

These two divisions comprise all *Séminées*. Such plants always have in the pistil one or more ovules with a covered nucellus. Later, during the simultaneous development of the embryo and albumen, each ovule increases in size, and becomes at last a seed as distinct in the ripe fruit as it was in the pistil. In the fruits of these plants, the ovules are permanent, that is to say, throughout their development they preserve their autonomy. "En un mot, elles sont séminées, parce qu'elles étaient pérovulées." According to the character of the integuments, they are divided into the two secondary groups, *Unitegminées*, and *Bitegminées*. The latter are higher in rank than the former.

The primary group of the *Inséminées* presents a larger number of divisions. Certain of their plants have in their pistil one or more ovules, like those of the *Séminées*, that is to say, they have a nucellus enveloped with one or two integuments. In others, the carpel produces one or more ovules, but the nucellus is devoid of any integument, remaining naked, *Integuminé*. In others, still, the carpel is cut into one or more folioles, but the foliole is not differentiated into petiole and limb, and it does not produce any conical emergence. The mother-cell of the endosperm is formed under the surface of the exoderm. Such an ovule with neither integument nor nucellus is reduced to a foliole, and is *Innucellé*. Finally, in some others, there is no formation of folioles for the separate production of the mother-cells of the endosperm. These arise from the general exoderm. The pistil is in short, without ovules, *Inovulé*.

These five differences in structure give rise to five secondary groups of *Inséminées*, named respectively *Bitegminées*, *Unitegminées*, *Integminées*, *Innucellées*, and *Inovulées*. Having no ovules in the pistil, the *Inovulées* can, of course, have no seeds in the fruit: but it is just as true that the other four minor groups do not. Those which really possess ovules are characterized by a blending of the peripheral layer of the ovule with the inner

wall of the ovary, through a distinct digestive process, and thus the ovule possesses only a transitory existence as such.

The vast majority of Phanerogams are, of course, *Séminées*. Under the head of Bitegminate in this class come all the Gymnosperms and most of the Gamopetalous Dicotyledons. The Bitegminate comprise all the Monocotyledons, with the exception of *Gramineæ*, and most Dialypetalous and Apetalous Dicotyledons.

The primary group of *Inséminées* is much smaller but much more diversified. The author at this point calls attention to the inexactness of the designation *Spermaphytes*, and shows that there is no absolute necessity for Phanerogams, as such, to have what we have called seeds. The importance of this group of *Inséminées* from a systematic point of view has been emphasized by Professor van Tieghem, in the communications above referred to.

Of these, the *Inovulées*, or *Loranthaceæ* as enlarged, are divided into ten orders, all of which are characterized by the absence of true ovules. It will, perhaps be remembered that his views in regard to certain Loranths, propounded by van Tieghem, in 1869, in his study of *Viscum*, and unfavorably criticised at the time, have been confirmed in good degree by Treub and by Johnson. These ten orders are divided into 21 tribes and 141 genera, more than one hundred of which are new to science.

The *Innucellées*, or Santalineæ (including the Olacales) are, as re-arranged, placed in two alliances, nine families, nine tribes, and fifty genera, of which five are new.

The *Inséminées* with a naked nucellus constitute the new subdivision, *Anthobolinées*, a single family, with four genera.

The Unitegminate *Inséminées* are the *Icacinées*. The two alliances comprise fifty-two genera, many of which are new.

The Bitegminate *Inséminées* have two sections, three alliances, seven families, and more than three hundred genera. In this group the author places the grasses, and notes the wide separation between *Gramineæ* and *Cyperaceæ*.

Some idea of the results following the adoption of Professor van Tieghem's system can be gained by a slight comparison of it with two accepted methods of classification. In Bentham and Hooker's *Genera Plantarum*, the plants which are here called *Inséminées* are placed in four families, namely *Loranthaceæ*, *Santalaceæ*, *Olacaceæ*, *Balanophoraceæ*, with about 90 genera. In Engler's treatise, now in course of publication, *Myzodendraceæ* is separated from *Santalaceæ*, and *Icacineæ* from *Olacaceæ*, making six families and 120 genera. Van Tieghem makes of these, 36 families and 260 genera. Moreover, he states that this differentiation cannot stop here: increased knowledge of some of the forms will necessitate still further subdivision.

In the last paper of the present series, the author considers the *Séminées*, dividing them first of all into *Astigmates* and *Stigmates*. These correspond very nearly to the Gymnosperms and Angiosperms, or, otherwise, *Archigoniées* and *Anarchegoniées*, or

still further, *Merantheridiées* and *Holantheridiées*. After pointing out the slight inadequacy or, perhaps, inappropriateness of these latter terms, the author proceeds to a consideration of the place which Gymnosperms occupy in the order of development. It is at this point that he states unequivocally his belief that it is incorrect to regard Gymnosperms as standing lower in the scale than the Angiosperms. For his reasons we must refer the reader to the memoir.

On page 924 is given a synoptical table of the highest interest. In this the *Séminées* are exhibited in their new relations, and here the strangest collocations result. One feels, in looking at them, much as he does in reviewing Agardh's pages in which *Lentibularieæ*, *Droseraceæ*, *Nepentheæ*, *Cephaloteæ*, etc., are brought near together. The Monocotyledons (with the exception of the excluded *Gramineæ*) stand next to *Nymphæaceæ*, and so on. Without a transfer of the table itself to our pages, it would be useless to dwell on the singular and suggestive juxtapositions and parallelisms. One lays down the treatise with the conviction that the author has done a great service in calling attention once more to the too much neglected field of embryogeny and correlated development.

While examining Professor van Tieghem's interesting treatise, it is impossible to avoid thinking of the difficulties which beset his classification, on palæontological grounds, and also, of the exceptions which occur at different points. Among these exceptions are some which the author candidly calls attention to, such as the genus *Helleborus in Ranunculaceæ*, *Lupinus in Leguminosæ*, etc. The fact that these genera, which have plants with ovules possessing only one integument, belong at present in Natural Orders characterized by ovules with two integuments, is extremely interesting, and should lead to a reinvestigation of the plants in question with a view to ascertaining whether they may not possess temporarily the missing integument. Many such inquiries will naturally suggest themselves.

As a necessary conclusion of his work, Professor van Tieghem insists that structural characters drawn from the corolla and the relations of the pistil to the verticils of the flower are generally invoked too early in the systematic classification of Phanerogams. He thinks these have their place only after more important matters have been settled; and these questions he finds in the ovule, seed and fruit. G. L. G.

IV. Miscellaneous Scientific Intelligence.

1. *On the Cause of Secondary Undulations Registered on Tide Gauges.*—In connection with the observations described in the article on the "Seiches" of the Bay of Fundy, by A. W. Duff, in the May number of this Journal, it is interesting to note that a paper was read by Napier Denison, of the Toronto Observatory, before the Canadian Institute, on January 16th, on the secondary undulations found upon self-recording tide gauges.

The writer remarks that his attention was called in June, 1896, to some rapid changes of water level on Lake Huron, at the mouth of the river Kincardine. Here the observed rise and fall appearing to be regular, a set of observations were made with a tempoary float. By this means a uniform rise and fall of about three inches were found to occur, averaging nine minutes, that is about eighteen minutes for each undulation; the float moved up stream at the rate of a mile and one-half an hour.

This phenomenon led the author to discuss the analogous observations made at Toronto and St. John, in connection with the changes of barometric pressure; these being plotted on a large scale. The conclusion is reached that the secondary undulations described are due to atmospheric waves or billows started in the upper atmosphere. Some special points in this connection are treated of at length. The author concludes by remarking that, if the above explanations are correct, it might be of great value, in place of eliminating these secondary undulations, when tabulating the primary ones, to increase the amplitude of these secondaries, by lengthening the cylinder, to use one sheet per day to prevent confusion of traces, and make a special study of them, respecting their intensity and time interval, in conjunction with synoptic charts during different types of weather. It appears as if these gauges are extra sensitive barometers, locally forewarning the approach of important storm centers many hours previous, in fact, during a rising or stationary barometer and before the shift of wind.

2. *The Zoölogical Bulletin.*—It is announced that "The Zoölogical Bulletin" is to be published as a companion serial to the "Journal of Morphology." It is designed to give prompt publication to shorter contributions in animal morphology and general biology, with no illustrations beyond text-figures. It is to be expected that there will be sufficient material for at least six numbers a year of about fifty pages each.

The editorial work will be directed by C. O. Whitman and W. M. Wheeler, assisted by a number of collaborators, whose names will appear on the title-page. The subscription price per volume of six numbers will be $3.00, and single numbers will be sold separately at 75 cents each. The first number is now nearly full, and may be expected to appear in June. (Ginn & Company, Publishers.)

OBITUARY.

Alvan Graham Clark, the astronomer, died of apoplexy in Cambridge, Mass., June 9, 1897. He was born in Fall River, Mass., July 10, 1832, and was the youngest of two sons. Having received a good school education and prepared himself for the profession of a practical machinist, he entered into partnership, on coming of age, with his father, Alvan Clark, and his brother in the manufacture of optical instruments. The unrivalled skill of all three in the figuring of large objectives, and their great achievements, are too familiar to need comment. The youngest

brother possessed his full share of the family genius, in which ingenuity and persistency were equal factors, and he spent many years abroad in special study of Optics from its mechanical side as well as general astronomy. He was the discoverer of fourteen double stars and was a member of the eclipse expedition to Spain in 1870 and to Wyoming in 1878. He is best known as the discoverer of the Companion to Sirius, which he found Jan. 31, 1862, while testing the 18-inch glass just then finished by the firm for the Dearborn Observatory. For this he received the Lalande prize from the Academy of Sciences of France. A medal of honor was given the firm by the Russian Government for the 30-inch refractive of the Royal Observatory at Pulkova.

The untimely death some years since of his son Alvan, the only male descendant of the family, destroyed the hope which the scientific world shared with the father that the work of the firm might be carried on by the strain which originated it, and Mr. Clark proceeded systematically to preserve the results of his experience, by means of instruction to skilled workmen, especially to Mr. Carl Lundin, his associate for twenty-five years and his natural successor.

It is impossible to separate the work of the three members of the firm. It is best characterized by the remark that almost without exception the construction of lenses of the first class has been for over thirty years wholly in their hands. Their work came to a fitting and not improbably an inevitable conclusion when Mr. Clark delivered to the Yerkes Observatory a few weeks since its 40-inch objective. Mechanical difficulties which good judges thought insuperable beyond 30 inches have been overcome up to 40 inches, and Mr. Clark was already contemplating a still larger lens, but it may well be that the rigidity of glass will fail under the strain of greater weight. The last test of the Yerkes lens before it was shipped from Cambridge indicated a change of definition in different positions in its cell. If this be true, a limit, this time unsurmountable, has been well nigh reached; in view of this it will be eminently proper to say that the firm of Alvan Clark and Sons has written a chapter in Astronomy to which it will be as impossible to add a line as to subtract one. W. B.

Carl Remigius Fresenius, Professor of Chemistry in the Agricultural Institute at Wiesbaden, died in that city on the 11th of June. He was born in Frankfort a. M. on the 28th of December, 1818. In his early life he studied pharmacy and it was while a pharmacist's assistant in Frankfort that his first chemical work was done. In 1845 he removed to Wiesbaden, became the director of the renowned chemical laboratory there, and developed that remarkable ability which finally made him the leading authority in Europe on analytical chemistry. His handbooks of chemical analysis, now known and used all over the world, were published, the qualitative part in 1841 and the quantitative part in 1846. The "Zeitschrift für analytische Chemie" was founded by him in 1862 and at once became the center of analytical investigations. For some years he had relinquished his share in the more active management of the laboratory to his son, who will doubtless succeed him.

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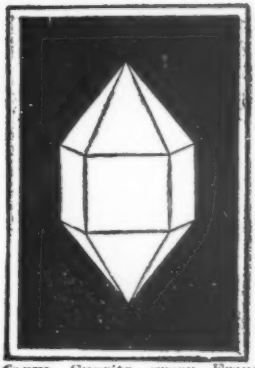

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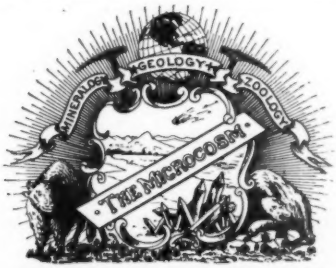

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Rockwood (2),	5 to 8 "	Beaver Creek (6),	25 "
Doña Inez (3),	10 to 15 "	Kessen,	15 "
Llano del Inca (3),	8 to 12 "	Pultusk,	13 to 15 "

(1) Described in this Journal Sept., 1895. (2) Ibid Nov., 1887. (3) Proc. Roch. Acad. Sci., Vol. 1. (4) This Journal Aug., 1888. (5) Ibid July, 1893. (6) Ibid June, 1894.

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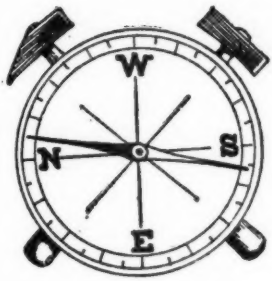

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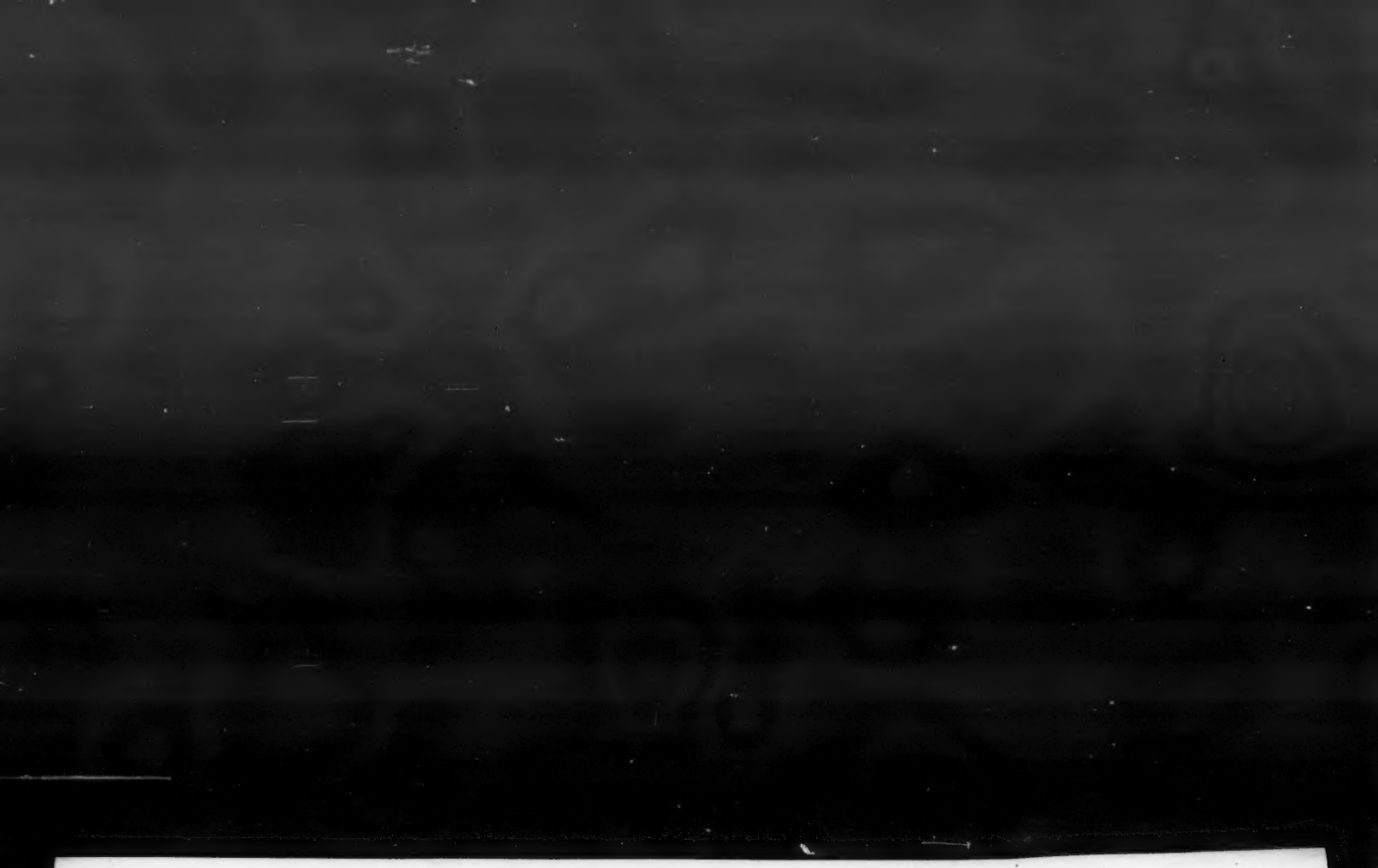
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